(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 593 191 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
12.07.2000 Bulletin 2000/28

(51) Int. Cl.[7]: **H04R 1/40**, H04R 3/12, H04R 1/28

(21) Application number: **93307878.4**

(22) Date of filing: **04.10.1993**

(54) **Multiple driver electroacoustical transducing**
Elektroakustischer Wandler mit mehreren Lautsprechern
Transduction électroacoustique à plusieurs haut-parleurs

(84) Designated Contracting States:
AT BE CH DE DK ES FR GB GR IE IT LI LU MC NL PT SE

(30) Priority: **15.10.1992 US 961397**

(43) Date of publication of application:
20.04.1994 Bulletin 1994/16

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Description

[0001] The present invention relates in general to electroacoustical transducing and more particularly concerns a novel loudspeaker system for illuminating with sound a predetermined solid angle centered at the loudspeaker system over substantially the full range of audio frequencies.

[0002] CH-A-403865 discloses a flexible support for supporting an array of driver assemblies in which the support can be twisted to alter the orientation of the drivers attach thereto. DE-A-821219 discloses a speaker array with speaker drivers facing in different directions.

[0003] According to the invention, there is provided a loudspeaker system comprising:

> at least three loudspeaker driver assemblies, each operative over a plurality of octaves in the audio frequency range and having an axis and a span(s);
> a support structure supporting the loudspeaker driver assemblies; characterised in that:
> the loudspeaker assemblies are in fixed substantially contiguous relationship substantially along an arcuate surface of predetermined width, with the axis of each of the driver assemblies having a component perpendicular to and a component parallel to the arcuate surface with each of the driver assemblies oriented in a prescribed direction and co-acting to illuminate a predetermined solid angle centred at the loudspeaker system with sound substantially uniformly over the plurality of octaves.

[0004] Typically, the loudspeaker driver assemblies include first and second end driver assemblies, a central driver assembly and at least first and second intermediate driver assemblies between the first and second end driver assemblies, respectively, and the central driver assembly. The relative positioning of the driver assemblies establishes the predetermined solid angle over a frequency range in which the wavelength λ is between about 2L and about L. The curvature of the arcuate surface establishes the solid angel over a frequency range where λ is between about L and about L/2 and the position of the intermediate driver assemblies establishes the solid angle for the frequency range where λ is between about L/2 and twice the average spacing d between contiguous driver assemblies. There may be electrical circuitry, defined as shading networks, connected to some of the loudspeaker driver assemblies for establishing the solid angle for a frequency range where λ is between about 2d and about d, the shading networks typically being effective substantially only in the latter frequency range. Typically, the shading networks affect mainly the radiation from the end driver assemblies. According to an aspect of the invention, the spacing between contiguous driver assemblies is the same except for a different spacing between at least two of the driver assemblies for establishing the solid angle for the frequency region for λ between about d and about d/2 through spatial dithering. Spatial dithering is departure from regular spacing between adjacent driver assemblies. The orientation of each of the driver assemblies establishes the solid angle for the frequency range where λ is considerably less than the span S across each driver assembly, typically the diameter of a driver for a single-drive assembly.

[0005] According to another aspect of the invention, the support structure comprises a ported enclosure. The ported enclosure is typically arcuate and has a rear concave surface normally facing a room bounding surface and formed with at least one port opening so that when the enclosure contacts a room bounding surface, each port opening remains uncovered.

[0006] Other features and advantages will become apparent from the following detailed description when read in connection with the accompanying drawings in which:

> FIG. 1 is an isometric view of an exemplary embodiment of the invention;
> FIGS. 2, 3, 4 and 5 are front, side, top and rear views, respectively, of the exemplary embodiment;
> FIG. 6 is a block diagram illustrating the logical arrangement of a system according to the invention; and
> FIGs. 7A-X are schematic circuit diagrams of a controller in an exemplary embodiment of the invention showing specific parameter values.

[0007] With reference now to the drawings and more particularly FIG. 1 thereof, there is shown an isometric view of an exemplary embodiment of the invention with each loudspeaker driver assembly consisting of a single driver. A support structure 11, typically made of molded plastic, such as high-impact poly-styrene, supports end loudspeaker drivers 12 and 13, intermediate loudspeaker drivers 14 and 15 and center loudspeaker driver 16 substantially on an arcuate surface of length L and width w corresponding substantially to the diameter of each driver with each driver oriented in a different direction. The average separation between centers of adjacent drivers is d.

[0008] The same reference numerals identify corresponding elements throughout the drawing. Referring to FIGS. 2, 3, 4 and 5, there are shown front, side, top and rear views of the exemplary embodiment.

[0009] Referring to FIG. 6, there is shown a block diagram of the exemplary embodiment illustrating the logical arrangement of using active equalization and shading networks. An active equalizer 21 receives an input audio signal to be reproduced on input 22 and energizes power amplifier 23. Power amplifier 23 energizes drivers 12-16 in phase and in series with end drivers 12 and 13 shunted by shading network 17, operative to provide phase shift or amplitude attenuation only

within a predetermined frequency range as explained below.

[0010] Having described the physical arrangement of a loudspeaker system according to the invention, its mode of operation will be described. The invention embodies a number of design techniques to provide control of the directional characteristic from lower frequencies, where the wavelength λ is about twice the whole array, up to higher frequencies where the wavelength is much less than the span of each driver. Combining the different techniques according to the invention builds a bridge from the lower to the higher frequencies to control the directional characteristics to be substantially the same across the entire frequency region. Each technique is used to control directionality substantially within only one frequency region and when applied in that region, it almost does not affect other regions.

[0011] The frequency range referred to by the wavelength λ is specified relative to array dimension L, typically the array length and average spacing between the centres of contiguous drivers d. The regions of control are listed in order of increasing frequency.

[0012] The lowest frequency region of control is where A is between about 2L and about L. In the exemplary embodiment, L is the length of the array having a width w corresponding substantially to the diameter of each driver. However, it is within the principles of the invention to expand the width dimension and/or the length dimension, by increasing the number of drivers in either or both directions. According to the invention, the drivers are initially positioned according to the rule that the more directional the array is to be in a selected plane through the array, the greater extent of the array provided as projected in that plane. For example, the array shown in the drawing is more directional in the vertical plane than in the horizontal plane. Furthermore, the drivers are preferably packed together as closely as practical. Reducing spacing between drivers increases the frequency at which the interdriver interference effects become a problem.

[0013] The next frequency region of control is where λ is greater than about L/2 yet smaller than about L. In this frequency region arcing controls the directional characteristics. Arcing may be achieved by bowing the outer and intermediate drivers backwards, while systematically positioning them on the surface of a substantially arcuate surface, typically a portion of a sphere or an ellipsoid. In this frequency region, the outer and center drivers 12, 13 and 16 are mostly responsible for establishing the directional characteristics because they substantially determine the overall shape of the array. An arcuate surface of small radius of curvature produces a wide radiation pattern.

[0014] The next frequency region of control is where λ is between about L/2 and about 2d. In this region coarse positioning of the intermediate drivers, such as 14 and 15, controls the directional characteristics. This coarse positioning occurs while maintaining the overall shape of the array as determined in the arcing frequency region.

[0015] Moving up in frequency, the next frequency region of control is where λ is between about 2d and about d. In this region, an electrical shading network, or networks connected to some drivers effectively control directional characteristics even in the presence of strong interdriver interference. Typically, shading networks, such as 17, furnish phase and/or magnitude shading to alter phase and/or magnitude of energy having spectral components only in this frequency range energizing outer drivers 12 and 13. A feature of the invention is that the shading networks are substantially only effective in this frequency range so that all drivers are substantially fully operational outside this band as if the shading networks were absent. Also the amounts of attenuation introduced are relatively small, typically about 3 dB. By attenuating the outer drivers, interference between drivers is decreased within the predetermined solid angle in this frequency range only.

[0016] In the next frequency region of control λ is between about d and about d/2. In this region, spatial dithering controls the directional characteristics. Systematically positioning drivers forwards, backwards or sidewards by small amounts to interrupt the regular spacing of the array accomplishes spatial dithering. The position departures from regularity are relatively minor because the wavelength at these frequencies is comparable to driver size. It has been discovered that any one driver may be involved in providing spatial dithering. The result of spatial dithering is to weaken dominant side lobes. These undesirable lobes are strongest when interdriver spacing is regular.

[0017] The highest frequency region of control is the region where λ is much less than the diameter of the drivers. At these frequencies the drivers have each become more directional. By pointing the individual drivers in respective different directions, they may be aimed to provide the desired radiation pattern in this frequency range. The basic rule is that if energy is desired in a given direction, in this frequency range some driver must point in that direction.

[0018] Another feature of the invention resides in port structure that avoids unequal acoustic impedances of the resonant enclosure as seen by the various drivers while ensuring that port openings, such as 18 and 18' (FIG. 5) remain unblocked when the assembly is normally mounted against a wall.

[0019] A multi-driver ported loudspeaker system with a single enclosed volume is typically characterized by a problem of unequal acoustic impedances of the resonant enclosure as seen by the various drivers. This is typically referred to as uneven loading of drivers. Uneven loading of drivers may imply that at least one driver experiences an air pressure on its cone which is substantially different from that of other drivers at some specific frequency. Also, uneven loading may imply that

one or more drivers experience air pressure that is not substantially uniform over the rear of the radiating surface of the driver, so that, for example, the pressure at one part of the cone is substantially different from that of another part.

[0020] The consequences of uneven loading of drivers are manifold. Since each driver does not experience the same sound pressure on its cone, the drivers do not work in phase and with similar magnitude, which may create a change in the overall directional characteristics or overall frequency response. More importantly, uneven loading typically leads to motion instability at high sound pressure levels which results in an early failure of driver soft parts such as the cone, the surround, and the spider. Early part failure is caused either by the nonsymmetrical air pressure on a driver which may result in nonsymmetrical cone motion of that driver or, by one or more drivers driven unstable by other drivers.

[0021] According to an aspect of the invention, the number of ports and the locations of the inner port termini are chosen so that the acoustic impedances of the resonant enclosure acting upon the various drivers are substantially the same. Using this technique overcomes the disadvantages mentioned above. Substantially even loading of drivers has been accomplished by balancing the distances from the various drivers to the various inner port termini. If nominally identical drivers are sharing the same enclosure having a single port and if the drivers are placed equidistantly from the inner port terminus, then the acoustic impedances as seen by the various drivers will be substantially the same. If the drivers share the same enclosure having more than one port opening, the location of the inner port termini are such that each driver sees substantially the same amount of port mass and box compliance.

[0022] In a typical application a minimum number of port openings is desired. Therefore, start out with one port located so as to make the distances from the inner port terminus to the drivers approximately equal. If this results in uneven loading of drivers, then add another port and again balance the port-driver distances. This procedure is repeated until a combination of number of ports and location of inner port termini has been achieved that results in substantially even loading of drivers.

[0023] The port tuning frequency is determined by the enclosure compliance and port mass. That is to say that box volume, total port cross-sectional area and port length are chosen to establish a port tuning frequency at a predetermined frequency where driver excursion becomes a minimum. The volume of each port is preferably as small as practical, flared at both input and output and of sufficiently large cross section so that port noise is substantially inaudible. The external port openings are preferably positioned on a substantially arcuate surface, thereby ensuring that the port openings remain unblocked when the assembly is normally mounted against a wall.

[0024] In the exemplary embodiment two ports are sufficient to obtain substantially equal acoustic impedances of the resonant enclosure as see by the various drivers. The two port tubes 18 and 18' are positioned on the rear substantially arcuate surface to ensure that they are unblocked when the loudspeaker system is normally mounted against a wall.

[0025] The location of the inner and outer port termini are shown in FIG. 5. As seen from the center of the loudspeaker assembly and in a rear view, the location of the inner port termini 18A and 18A' are offset vertically by about 12.75 cm (+5.1 inches) and by -12.75 cm, (-5.1 inches), respectively, and offset horizontally by about -2.54 cm (-1.0 inch) and about 2.54 cm (+1.0 inch), respectively. As seen from the center of the loudspeaker assembly and in a rear view, the location of the outer port termini are offset vertically by about 7.62 cm (+3.0 inches) and by about -2.54 cm (-1.0 inch) and about +2.54 cm (+1.0 inch), respectively. Each port is or tapered rectangular cross section about 12.75 cm (5.1 inches) long with a cross-sectional area of about 54.84 cm^2 (8.5 square inches) at each end and of about 47.1 cm^2 (7.3 square inches) midway between. The port tuning frequency in the exemplary embodiment is about 140 Hz.

[0026] In the exemplary embodiment of the invention, the drivers were 11.43 cm (4.5 inch) diameter Bose HVC (helical voice coil) drivers oriented as shown in the drawings to scale with the length dimension 60.96 cm (24 inches), the width dimension 16.51 cm (6.5 inches) and the depth dimension 20.32 cm (8 inches).

[0027] Referring to FIG.7, there is shown a schematic circuit diagram of a controller in this specific embodiment of the invention incorporating equalization circuitry and setting forth specific parameter values. Since those skilled in the art will be able to practice the invention by building the specific circuits shown in FIG. 7, this circuitry will only be briefly discussed to avoid obscuring the principles of the invention. Channel 1 and channel 2 are identical circuits that may, for example, receive left and right stereo input signals, respectively, in a stereo system. For a single channel, only one channel need be used to energize an associated power amplifier with the mode select switch S1 arms connected to the position 2 terminal. For voice-only reproduction, it is satisfactory and sufficient to energize the loudspeaker array with only the HF output signal with the mode select switch S1 arms connected to the position 1 terminals. For music, it is preferable to energize a separate bass amplifier energizing a separate bass reproducer, such as a BOSE 502B loudspeaker. Alternatively, an optional bass position may be selected by moving the mode select switch S1 arms to the position 4 terminals for energizing another amplifier connected to another bass reproducer, such as a BOSE ACOUSTIC WAVE CANNON loudspeaker.

[0028] While not specifically illustrated in the embodiment shown in the drawings, it is within the prin-

ciples of the invention to use other techniques in combination with some or all of the techniques mentioned above, such as deflectors or reflectors. Objects larger in extent than a wavelength may be used to redirect sound from one or more drivers. Adjustable deflectors or reflectors allow the user to vary directivity.

[0029] It is also within the principles of the invention to use diffractors in combination with some or all of the techniques mentioned above. Over a limited frequency range where the drivers are larger than a wavelength, placing a small object of some predetermined shape directly in front of a driver may perturb the directivity of that driver. This approach may be used to obtain a broader radiation pattern at some frequencies. The shape of such objects may be determined experimentally.

[0030] It is also within the principles of the invention to use active electronic equalization to provide the desired frequency response.

Claims

1. A loudspeaker system comprising:

    at least three loudspeaker driver assemblies (12-16), each operative over a plurality of octaves in the audio frequency range and having an axis and a span(s); and
    a support structure (11) supporting the loudspeaker driver assemblies; characterised in that:
    the loudspeaker assemblies are in fixed substantially contiguous relationship substantially along an arcuate surface of predetermined width, with the axis of each of the driver assemblies having a component perpendicular to and a component parallel to the arcuate surface with each of the driver assemblies oriented in a prescribed direction and co-acting to illuminate a predetermined solid angle centred at the loudspeaker system with sound substantially uniformly over the plurality of octaves.

2. A loudspeaker system according to claim 1, wherein:

    the relative positioning of the driver assemblies (12-16) establishes the predetermined solid angle over a frequency range in which λ is greater than substantially L but smaller than substantially 2L;
    the curvature of the arcuate surface establishes the solid angle over a frequency range where λ is greater than substantially L/2 but smaller than substantially L; and
    the direction in which each of the driver assemblies is pointed establishes the solid angle for the frequency range where λ is substantially smaller than the span(s), where λ is the wavelength of a spectral component, and L is the length of the array.

3. A loudspeaker system according to claim 2, wherein the loudspeaker driver assemblies (12-16) include:

    first and second end driver assemblies (12,13), a central driver assembly (16) and,
    at least first and second intermediate driver assemblies (14,15) between the first and second end driver assemblies respectively and the central driver assembly, and
    wherein the positioning of intermediate driver assemblies establishes the solid angle over a frequency range where λ is greater than substantially 2d but smaller than substantially L/2, where d is the average distance between the centres of adjacent driver assemblies.

4. A loudspeaker system according to claim 2, wherein at least one shading network is connected to some of the loudspeaker driver assemblies for establishing the solid angle for a frequency range where λ is greater than substantially d but smaller than substantially 2d, where d is the average distance between the centres of adjacent driver assemblies.

5. A loudspeaker system according to claim 4, wherein the some driver assemblies consist of the end driver assemblies (12,13).

6. A loudspeaker system according to claim 2, wherein the spacing between contiguous driver assemblies is the same except for a different spacing between at least two of the driver assemblies for establishing the solid angle for the frequency region where λ is greater than substantially d/2 but smaller than substantially d by breaking up the regularity of spacing, where d is the average distance between the centres of adjacent driver assemblies.

7. A loudspeaker system according to claim 1 or claim 2, wherein the support structure (11) comprises a ported enclosure.

8. A loudspeaker system according to claim 7, wherein the ported enclosure is a resonant enclosure and has ports (18,18') with inner termini located so that the acoustic impedance of the resonant enclosure as seen by a respective driver is substantially equal to that seen by each of the other drivers.

9. A loudspeaker system according to claim 7, wherein the support structure (11) has a rear con-

cave surface normally facing a room bounding surface and formed with at least one port opening (18,18') so that when the enclosure contacts a room bounding surface, each port opening remains uncovered.

10. A loudspeaker system according to claim 1 or claim 2, further comprising active electronic equalization circuitry (21) coupled to and co-acting with the loudspeaker system for establishing a predetermined substantially uniform frequency response over the plurality of octaves.

Patentansprüche

1. Lautsprechersystem, welches folgendes aufweist:

   mindestens drei Lautsprecher (12-16), die jeweils über mehrere Oktaven im Audiofrequenzbereich betrieben werden können, und eine Achse und eine Spannweite(n) haben; und
   eine Tragstruktur (11), die die Lautsprecher trägt; dadurch gekennzeichnet, daß:
   die Lautsprecher eine feste, im wesentlichen durchgehende Relativanordnung entlang einer gekrümmten Oberfläche mit vorbestimmter Breite haben, wobei die Achse jedes Lautsprechers eine Komponente senkrecht zu und eine Komponente parallel zu der gekrümmten Oberfläche hat, und wobei alle Lautsprecher in einer vorgegebenen Richtung orientiert sind, und zusammenwirken, so daß über die mehreren Oktaven ein vorbestimmter Raumwinkel, der am Lautsprechersystem zentriert ist, im wesentlichen gleichmäßig beschallt wird.

2. Lautsprechersystem gemäß Anspruch 1, bei welchem:

   die relative Lage der Lautsprecher (12-16) zueinander den vorbestimmten Raumwinkel bei einem Frequenzbereich ausbildet, bei welchem λ im wesentlichen größer als L aber im wesentlichen kleiner 2L ist;
   die Kurvenform der gekrümmten Oberfläche den Raumwinkel bei einem Frequenzbereich ausbildet, bei welchem λ im wesentlichen größer als L/2 aber im wesentlichen kleiner L ist; und
   die Richtung, in die jeder Lautsprecher zeigt, den Raumwinkel für den Frequenzbereich ausbildet, bei welchem λ im wesentlichen kleiner als die Spannweite(n) ist, wobei λ die Wellenlänge einer Spektralkomponente ist, und L die Länge des Arrays.

3. Lautsprechersystem gemäß Anspruch 2, bei welchem die Lautsprecher (12-16) umfassen:

   erste und zweite End-Lautsprecher (12, 13),
   einen zentralen Lautsprecher (16) und,
   mindestens einen ersten und einen zweiten Zwischen-Lautsprecher (14,15) zwischen jeweils dem ersten bzw. dem zweiten End-Lautsprecher, und dem zentralen Lautsprecher, und
   bei welchem die Lage der Zwischen-Lautsprecher den Raumwinkel bei einem Frequenzbereich ausbildet, bei welchem λ im wesentlichen größer als 2d aber im wesentlichen kleiner als L/2 ist, wobei d der durchschnittliche Abstand zwischen den Zentren von angrenzenden Lautsprechern ist.

4. Lautsprechersystem gemäß Anspruch 2, bei welchem mindestens ein Abblendnetzwerk mit einigen Lautsprechern verbunden ist, um den Raumwinkel für einen Frequenzbereich auszubilden, bei welchem λ im wesentlichen größer als d aber im wesentlichen kleiner als 2d ist, wobei d der durchschnittliche Abstand zwischen den Zentren von angrenzenden Lautsprechern ist.

5. Lautsprechersystem gemäß Anspruch 4, bei welchem die einigen Lautsprecher aus den End-Lautsprechern (12,13) bestehen.

6. Lautsprechersystem gemäß Anspruch 2, bei welchem der Abstand zwischen durchgehenden Lautsprechern gleich ist, mit Ausnahme von einem unterschiedlichen Abstand zwischen mindestens zwei Lautsprechern, um den Raumwinkel für den Frequenzbereich auszubilden, bei welchem λ im wesentlichen größer als d/2 aber im wesentlichen kleiner als d ist, indem die regelmäßige Beabstandung unterbrochen wird, wobei d der durchschnittliche Abstand zwischen den Zentren von angrenzenden Lautsprechern ist.

7. Lautsprechersystem gemäß Anspruch 1 oder 2, bei welchem die Tragstruktur (11) ein Gehäuse mit Öffnung aufweist.

8. Lautsprechersystem gemäß Anspruch 7, bei welchem das Gehäuse mit Öffnung ein Resonanzgehäuse ist, und Öffnungen (18,18') aufweist, deren Innenenden so angeordnet sind, daß die akustische Impedanz des Resonanzgehäuses, wie sie von einem jeweiligen Lautsprecher gesehen wird, im wesentlichen gleich ist mit derjenigen, wie sie von jedem anderen Lautsprecher gesehen wird.

9. Lautsprechersystem gemäß Anspruch 7, bei welchem die Tragstruktur (11) eine konkave Endfläche hat, die normalerweise einer Raumbegrenzungsflä-

che gegenüber liegt, und mit mindestens einer Austrittsöffnung (18,18') ausgebildet ist, so daß dann, wenn das Gehäuse eine Raumbegrenzungsfläche berührt, jede Austrittsöffnung freibleibt.

10. Lautsprechersystem gemäß einem der Ansprüche 1 oder 2, welche außerdem einen aktiven elektronischen Ausgleichsschaltkreis (21) aufweist, der mit dem Lautsprechersystem gekoppelt ist, und mit diesem zusammenwirkt, so daß über die mehreren Oktaven ein vorbestimmter, im wesentlichen gleichbleibender Frequenzgang erreicht wird.

Revendications

1. Système de haut-parleurs, comprenant :

- au moins trois ensembles de pilotes de haut-parleurs (12-16) pouvant fonctionner chacun sur plusieurs octaves dans la plage des fréquences audio et présentant un axe et un ou plusieurs écartements ou envergures ; et
- une structure de support (11) supportant les ensembles de pilotes de haut-parleurs ;
caractérisé en ce que
les ensembles de haut-parleurs sont placés dans une relation fixe essentiellement contiguë, essentiellement le long d'une surface courbe de largeur prédéterminée, de façon que les axes de chacun des ensembles de pilotes présentent une composante perpendiculaire et une composante parallèle à la surface courbe, et que chacun des ensembles de pilotes soit orienté dans une direction prescrite et coopère pour inonder de son, essentiellement uniformément, un angle solide prédéterminé centré à l'endroit du système de haut-parleurs, sur la pluralité d'octaves.

2. Système de haut-parleurs selon la revendication 1, dans lequel

- le positionnement relatif des ensembles de pilotes (12-16) établit l'angle solide prédéterminé sur une plage de fréquences dans laquelle λ est essentiellement supérieur à L, mais essentiellement inférieur à 2L ;
- la courbure de la surface courbe établit l'angle solide sur une plage de fréquences dans laquelle λ est essentiellement supérieur à L/2, mais essentiellement inférieur à L ; et
- la direction dans laquelle chacun des ensembles de pilotes est pointé établit l'angle solide pour la plage de fréquences dans laquelle λ est essentiellement inférieur aux écartements ou envergures, λ étant la longueur d'onde d'une composante spectrale et L étant la longueur du réseau.

3. Système de haut-parleurs selon la revendication 2, dans lequel
les ensembles de pilotes de haut-parleurs (12-16) comprennent :

- un premier ensemble de pilotes d'extrémité et un second ensemble de pilotes d'extrémité (12, 13), un ensemble de pilotes central (16) et au moins un premier ensemble de pilotes intermédiaire et un second ensemble de pilotes intermédiaire (14, 15) respectivement entre les premier et second ensembles de pilotes d'extrémité, et l'ensemble de pilotes central, et
- le positionnement des ensembles de pilotes intermédiaires établit l'angle solide sur une plage de fréquences dans laquelle λ est essentiellement supérieur à 2d mais essentiellement inférieur à L/2, d étant la distance moyenne entre les centres d'ensembles de pilotes adjacents.

4. Système de haut-parleurs selon la revendication 2, dans lequel
au moins un réseau de masquage est connecté à certains des ensembles de pilotes de haut-parleurs pour établir l'angle solide correspondant à une plage de fréquences dans laquelle λ est essentiellement supérieur à d mais essentiellement inférieur à 2d, d étant la distance moyenne entre les centres d'ensembles de pilotes adjacents.

5. Système de haut-parleurs selon la revendication 4, dans lequel
certains des ensembles de pilotes sont constitués par les ensembles de pilotes d'extrémité (12, 13).

6. Système de haut-parleurs selon la revendication 2, dans lequel
l'espacement entre ensembles de pilotes contigus est toujours le même, sauf pour un espacement différent entre au moins deux des ensembles de pilotes qui sont destinés à établir l'angle solide pour la zone de fréquences dans laquelle λ est essentiellement supérieure à d/2 mais essentiellement inférieure à d, en rompant la régularité d'espacement, d étant la distance moyenne entre les centres d'ensemble de pilotes adjacents.

7. Système de haut-parleurs selon la revendication 1 ou la revendication 2,
dans lequel
la structure de support (11) comprend une enceinte à orifices.

8. Système de haut-parleurs selon la revendication 7, dans lequel

l'enceinte à orifices est une enceinte résonnante et comporte des orifices (18, 18') munis de bornes intérieures placées de façon que l'impédance acoustique de l'enceinte résonnante, vue par un pilote respectif, soit essentiellement égale à celle qui est vue par chacun des autres pilotes.

9. Système de haut-parleurs selon la revendication 7, dans lequel
la structure de support (11) comporte une surface concave arrière venant normalement en face d'une surface de limitation d'espace et munie d'au moins une ouverture d'orifice (18, 18') de façon que lorsque l'enceinte vient en contact avec une surface de limitation d'espace, chaque ouverture d'orifice reste découverte.

10. Système de haut-parleurs selon la revendication 1 ou la revendication 2,
comprenant en outre
un circuit d'égalisation électronique actif (21) couplé et coopérant avec le système de haut-parleurs pour établir une réponse en fréquence prédéterminée, essentiellement uniforme, sur la pluralité d'octaves.

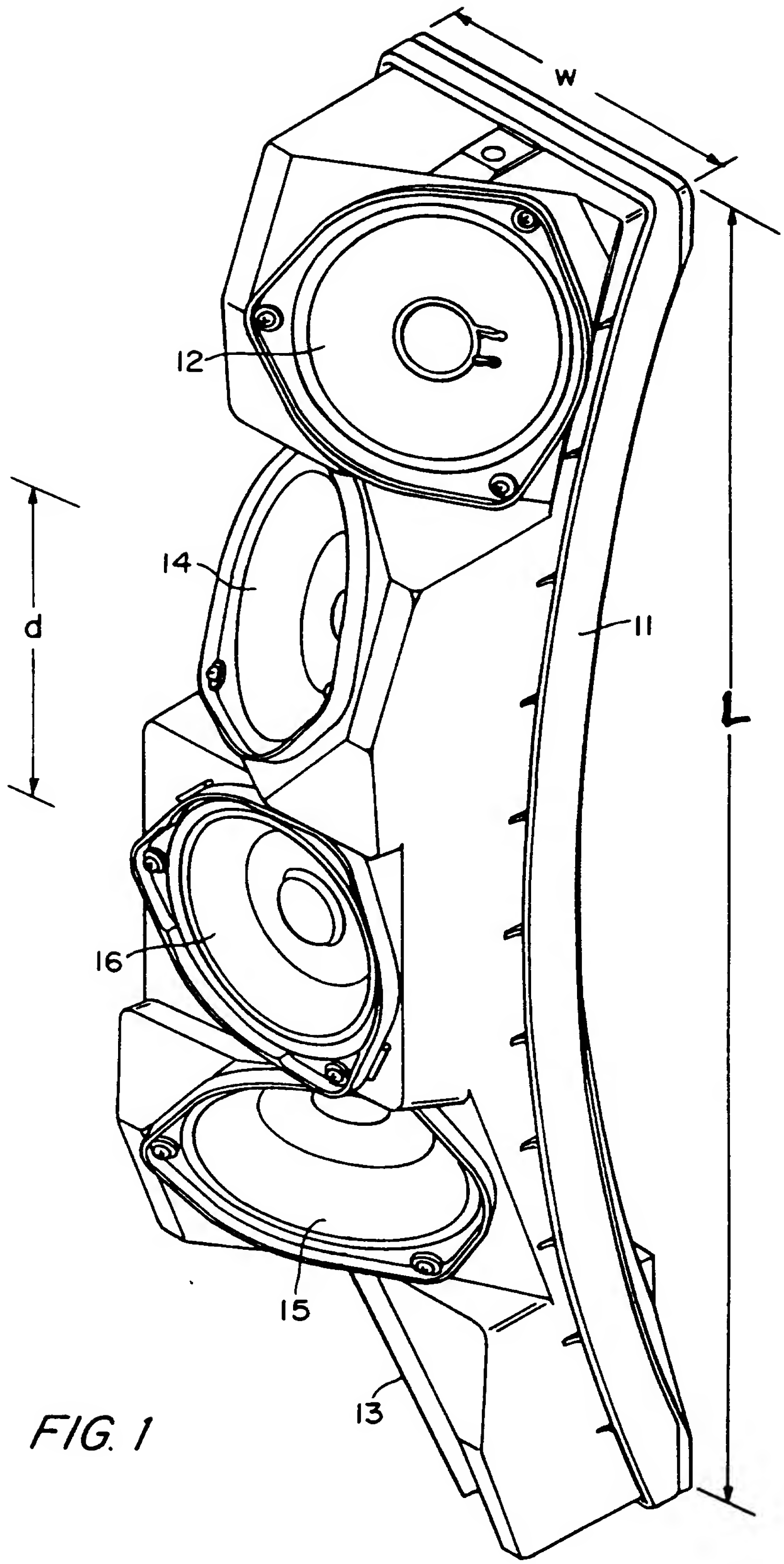


FIG. 1

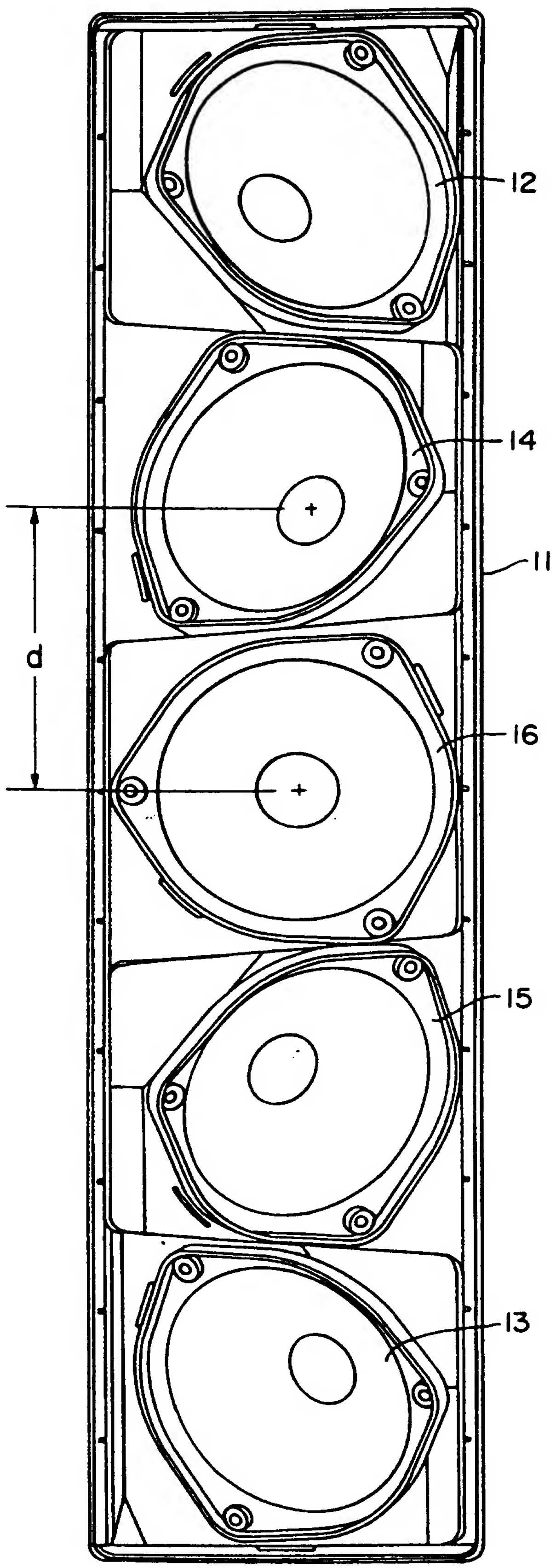


FIG. 2

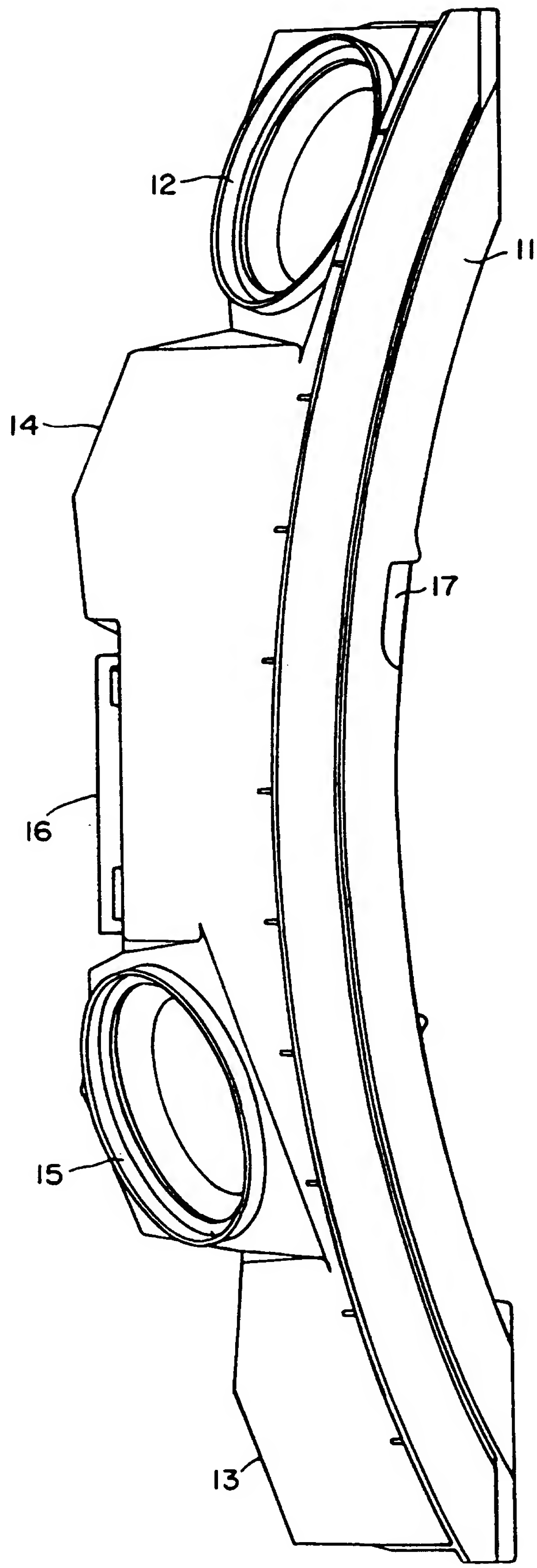


FIG. 3

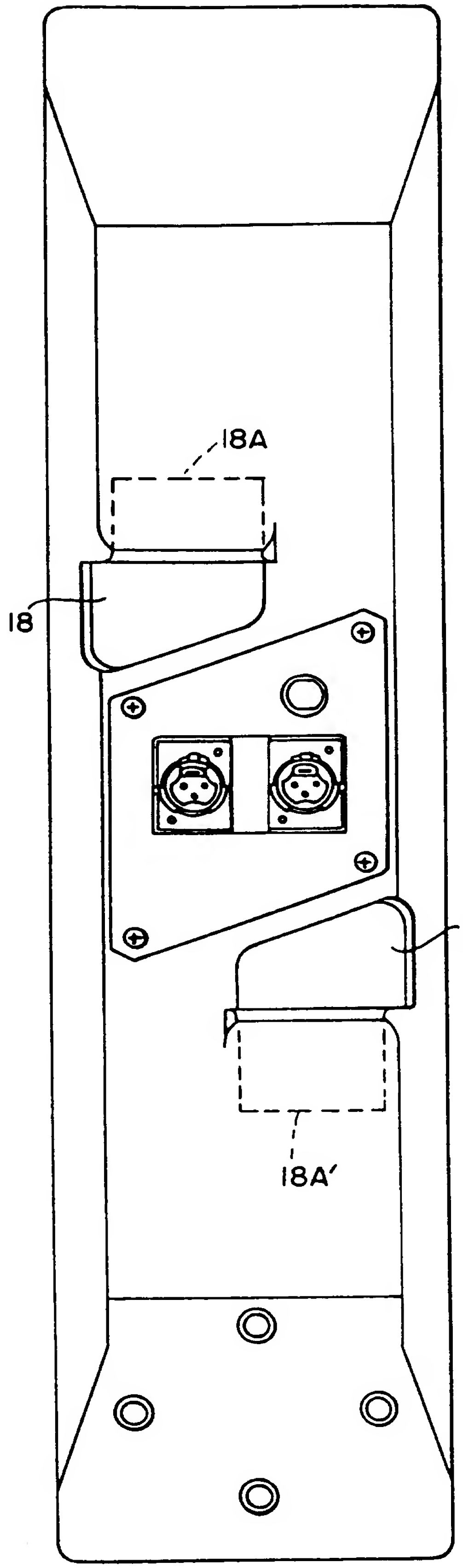


FIG. 5

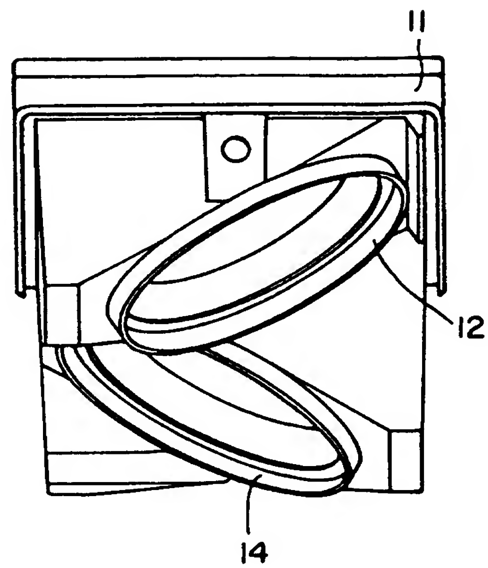


FIG. 4

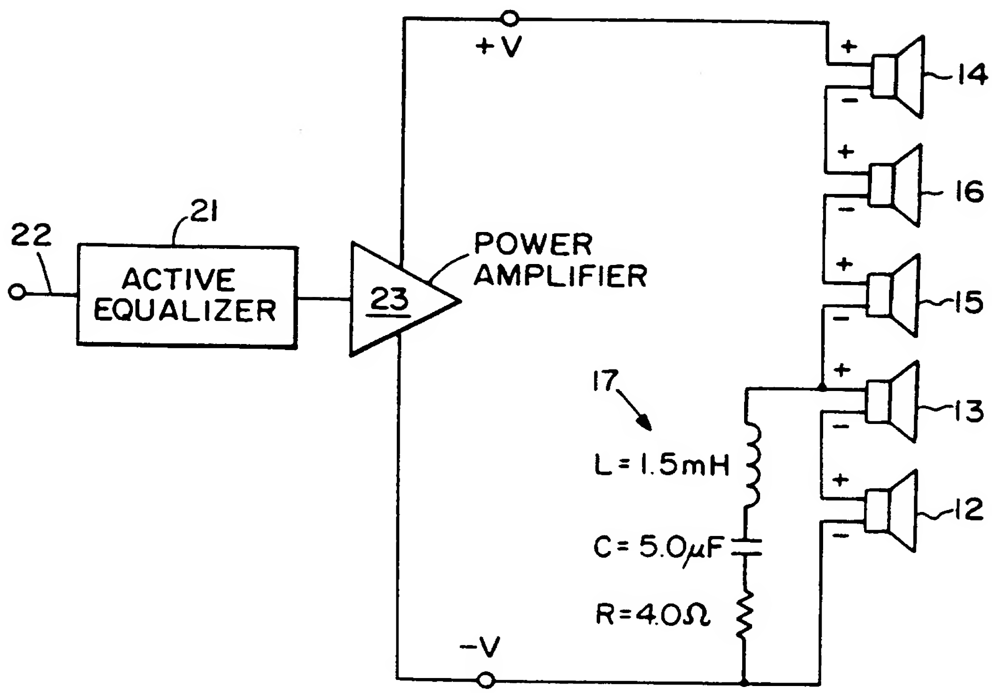
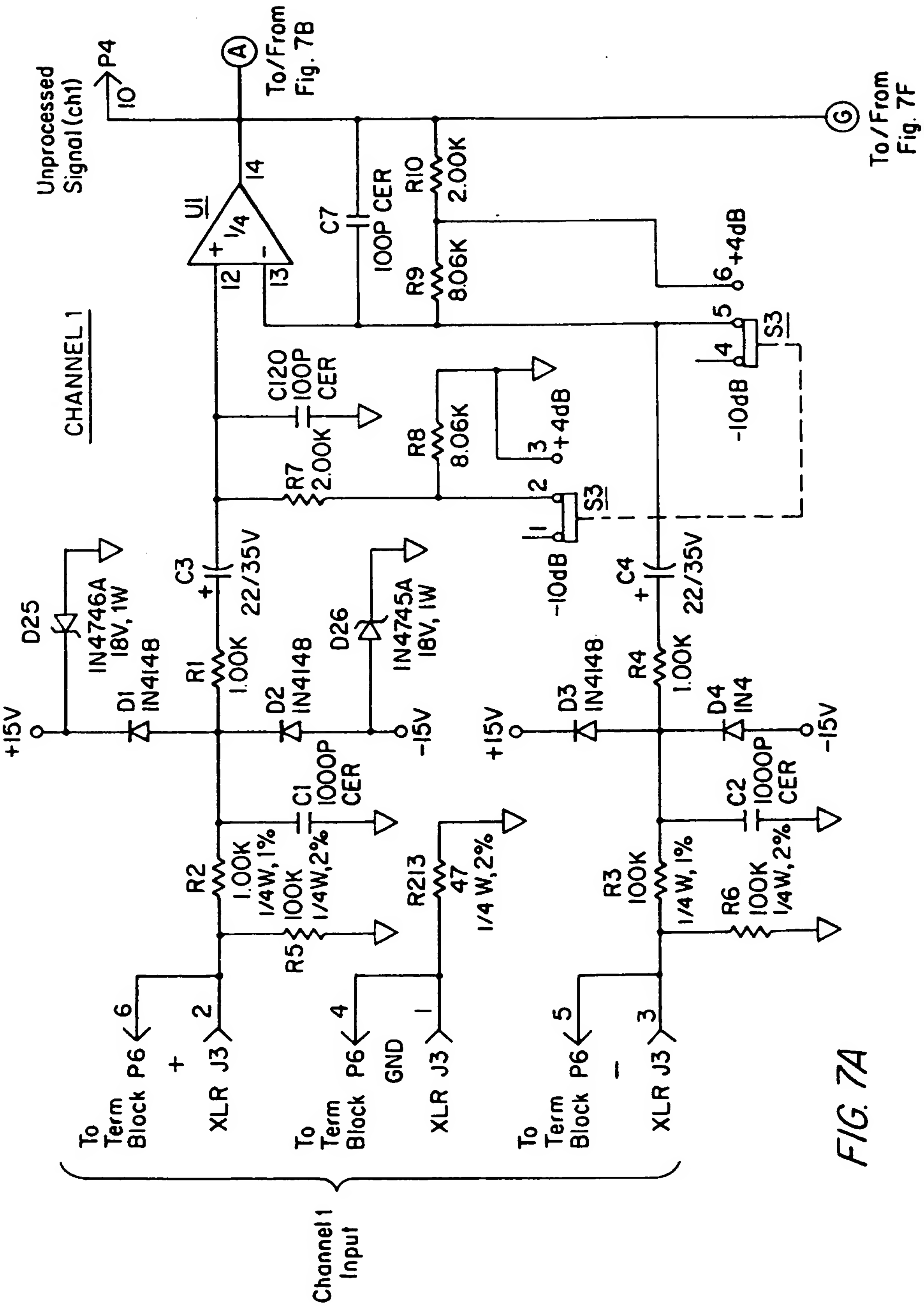

22
21
ACTIVE
EQUALIZER
23
POWER
AMPLIFIER
+V
-V
+
-
14
16
15
13
12
17
L = 1.5mH
C = 5.0μF
R=4.0Ω

FIG. 6



CHANNEL 1
Unprocessed Signal (ch1)
10
P4
A
To/From Fig. 7B
G
To/From Fig. 7F
U1
1/4
12
13
14
C7
100P CER
R10
2.00K
R9
8.06K
+4dB
-10dB
S3
C120
100P
CER
R7
2.00K
R8
8.06K
C3
22/35V
C4
22/35V
D25
IN4746A
18V, 1W
D26
IN4745A
18V, 1W
D1
IN4148
D2
IN4148
D3
IN4148
D4
IN4
R1
1.00K
R4
1.00K
+15V
-15V
C1
1000P
CER
C2
1000P
CER
R2
1.00K
1/4W, 1%
R5
100K
1/4W, 2%
R213
47
1/4 W, 2%
R3
100K
1/4 W, 1%
R6
100K
1/4W, 2%
To Term Block P6
XLR J3
GND
Channel 1 Input

FIG. 7A

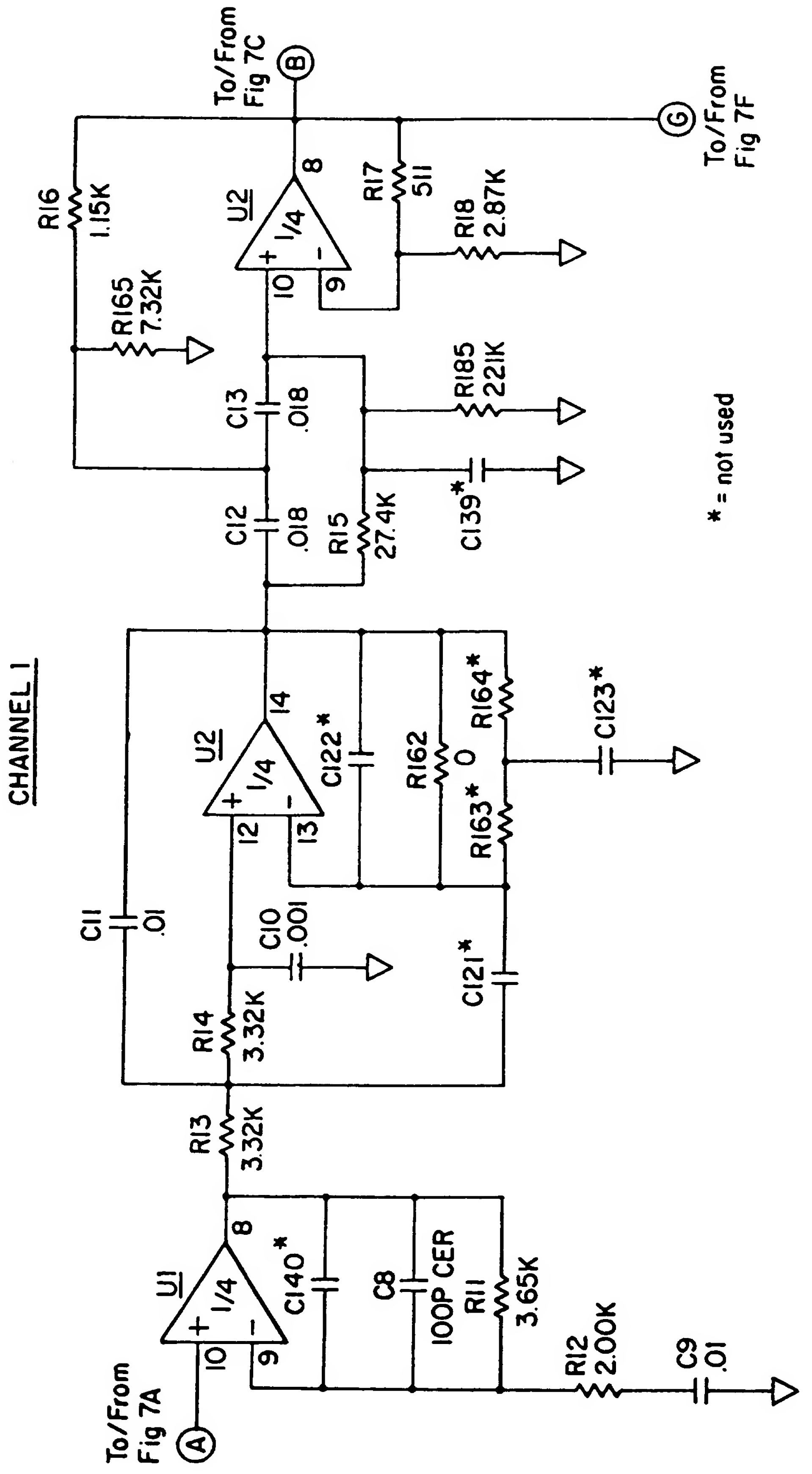

CHANNEL I
To/From
Fig 7A
A
U1
1/4
10
9
8
C140*
C8
100P CER
R11
3.65K
R12
2.00K
C9
.01
R13
3.32K
R14
3.32K
C11
.01
C10
.001
C121*
U2
1/4
12
13
14
C122*
R162
0
R163*
R164*
C123*
C12
.018
R15
27.4K
C13
.018
C139*
R185
221K
R165
7.32K
R16
1.15K
U2
1/4
10
9
8
R17
511
R18
2.87K
To/From
Fig 7C
B
G
To/From
Fig 7F
* = not used

FIG. 7B

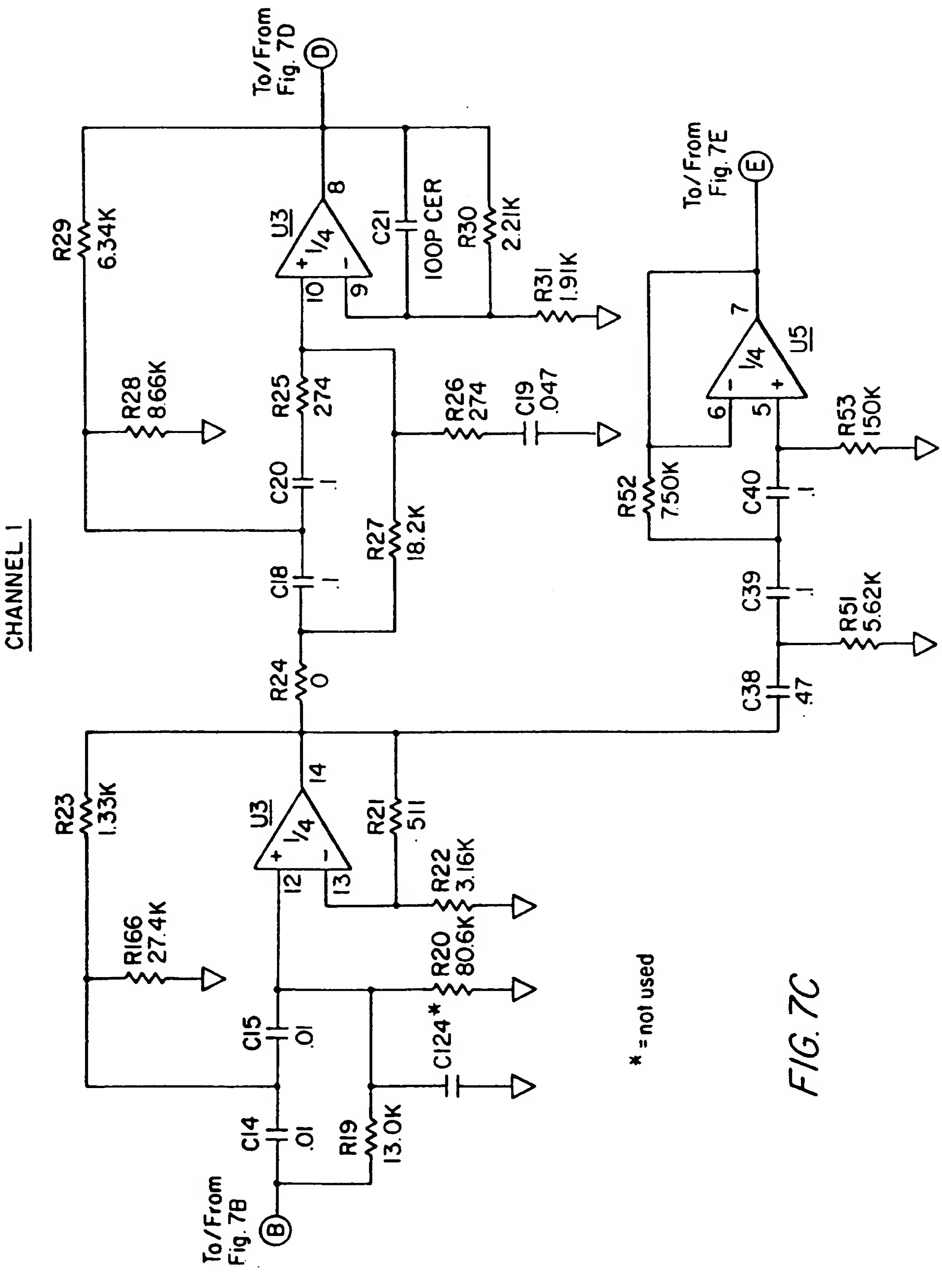

CHANNEL 1
To/From Fig. 7D
D
To/From Fig. 7E
E
To/From Fig. 7B
B
U3
1/4
U5
R29 6.34K
R28 8.66K
R25 274
R26 274
C19 .047
C20 .1
C18 .1
R27 18.2K
C21 100P CER
R30 2.21K
R31 1.91K
R24 0
R23 1.33K
R166 27.4K
R21 511
R22 3.16K
R20 80.6K
C15 .01
C14 .01
C124*
R19 13.0K
R52 750K
C40 .1
C39 .1
C38 .47
R51 5.62K
R53 150K
* = not used

FIG. 7C

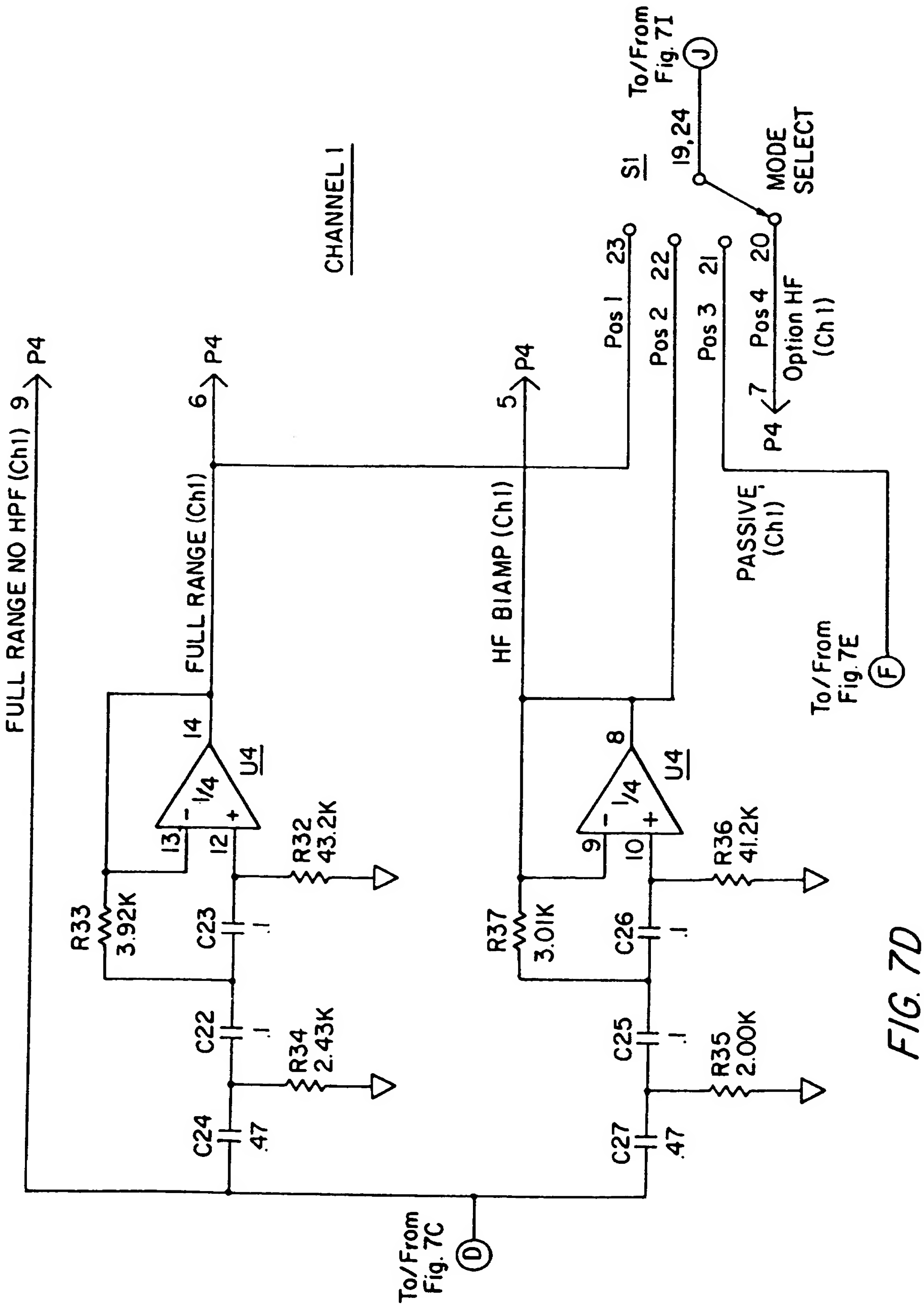

CHANNEL 1
FULL RANGE NO HPF (Ch1)
FULL RANGE (Ch1)
HF BIAMP (Ch1)
PASSIVE (Ch1)
P4
9
6
5
7
Pos 1
Pos 2
Pos 3
Pos 4
Option HF (Ch1)
23
22
21
20
19,24
S1
MODE SELECT
To/From Fig. 7I
J
To/From Fig. 7E
F
To/From Fig. 7C
D
U4
1/4
14
13
12
8
9
10
R33 3.92K
R32 43.2K
R34 2.43K
R37 3.01K
R36 41.2K
R35 2.00K
C23 .1
C22 .1
C24 .47
C26 .1
C25 .1
C27 .47

FIG. 7D

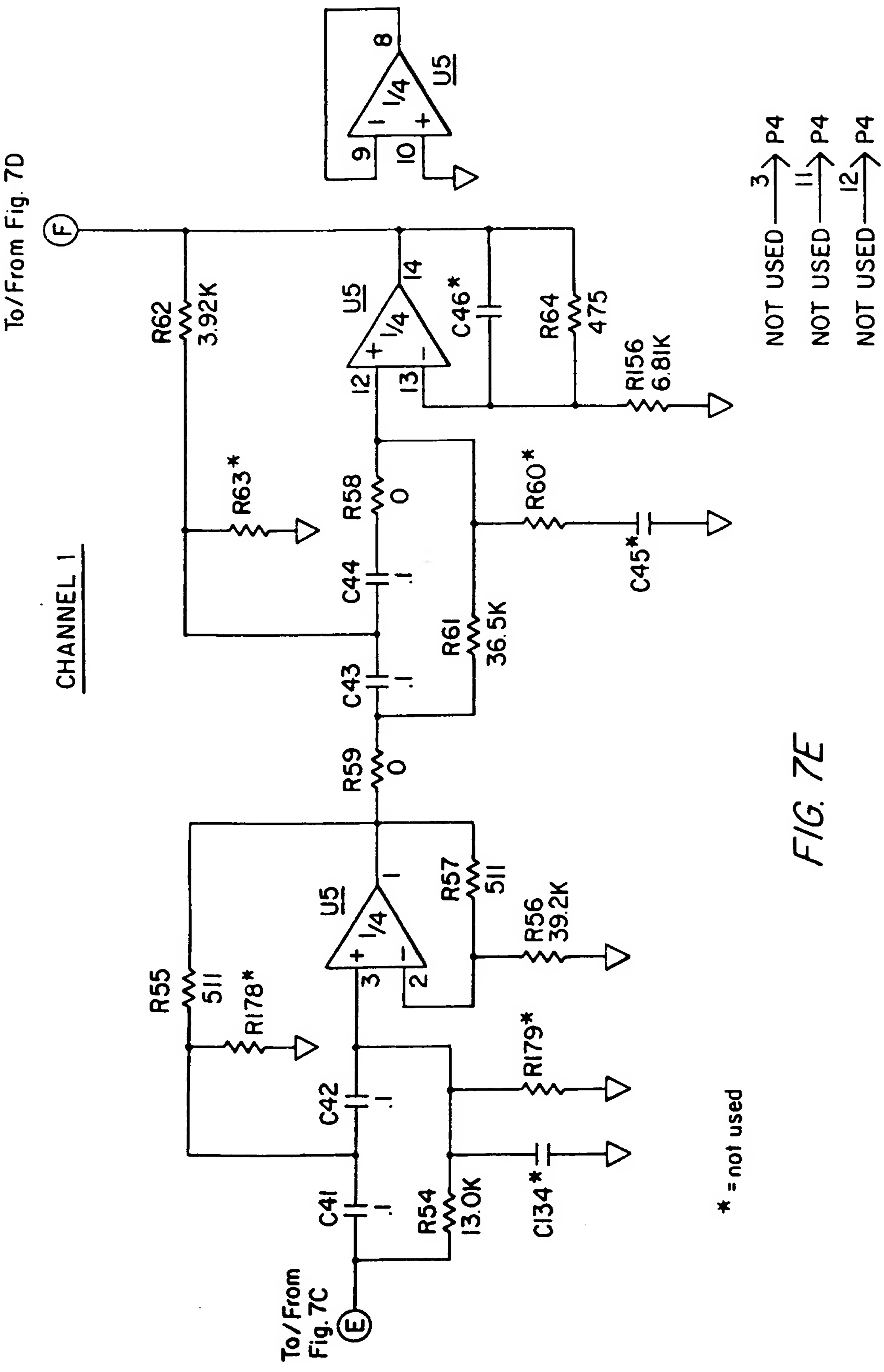

To/From Fig. 7D
F
CHANNEL 1
R62
3.92K
R63*
U5
1/4
8
9
10
12
13
14
C46*
R64
475
R156
6.81K
R58
0
C44
.1
R60*
C45*
R61
36.5K
C43
.1
R59
0
R55
511
R178*
3
2
1
R57
511
R56
39.2K
C42
.1
R179*
C41
.1
R54
13.0K
C134*
To/From
Fig. 7C
E
NOT USED
3
P4
NOT USED
11
P4
NOT USED
12
P4
* = not used

FIG. 7E

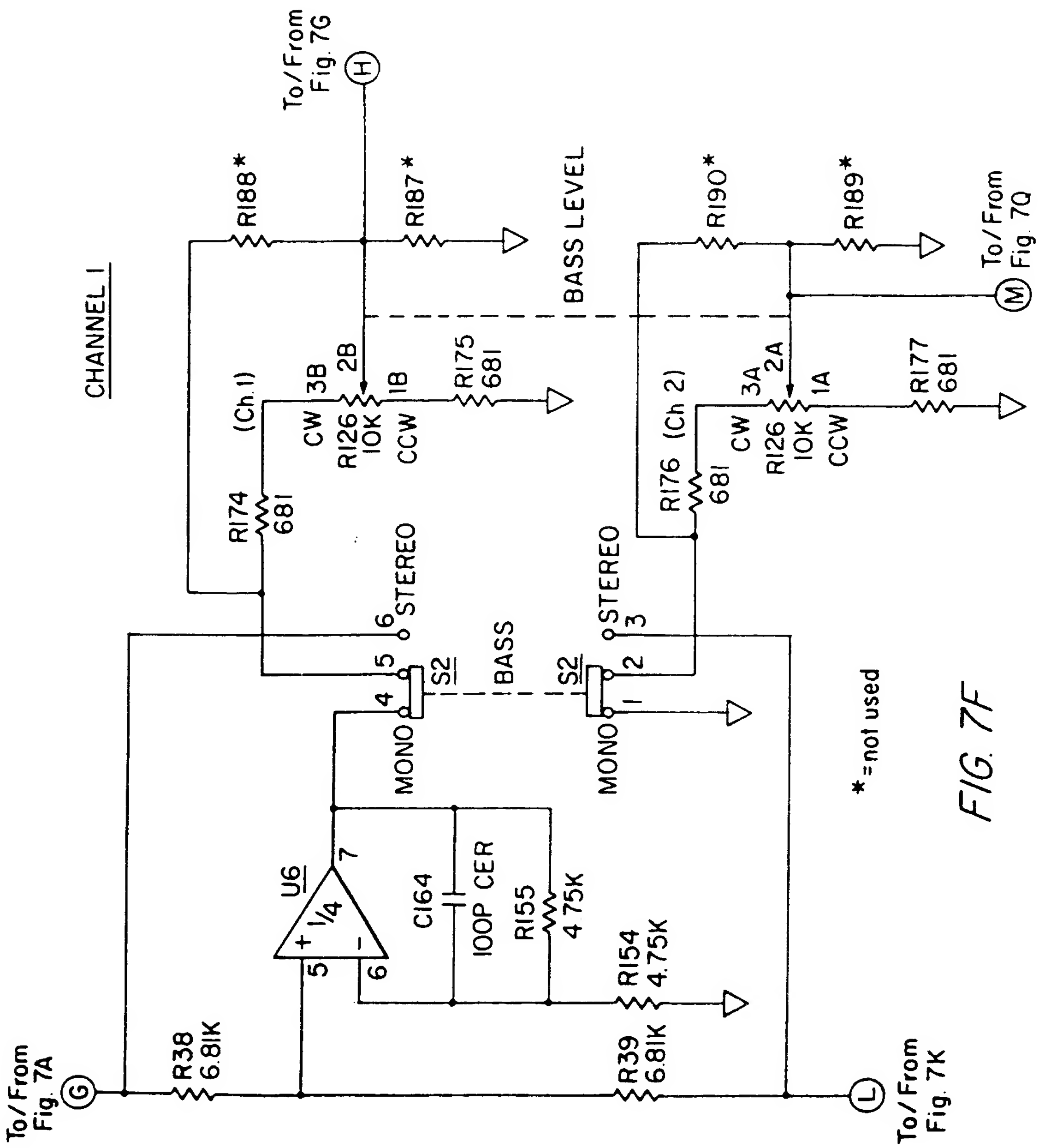

CHANNEL 1
To/From Fig. 7G
H
R188*
R187*
BASS LEVEL
R190*
R189*
To/From Fig. 7Q
M
(Ch.1)
CW
3B
2B
1B
R126
10K
CCW
R175
681
R174
681
R176
(Ch 2)
681
CW
3A
2A
1A
R126
10K
CCW
R177
681
STEREO
6
5
4
MONO
S2
BASS
S2
STEREO
3
2
1
MONO
U6
1/4
+
-
5
6
7
C164
100P CER
R155
4.75K
R154
4.75K
To/From Fig. 7A
G
R38
6.81K
R39
6.81K
L
To/From Fig. 7K
* = not used

FIG. 7F

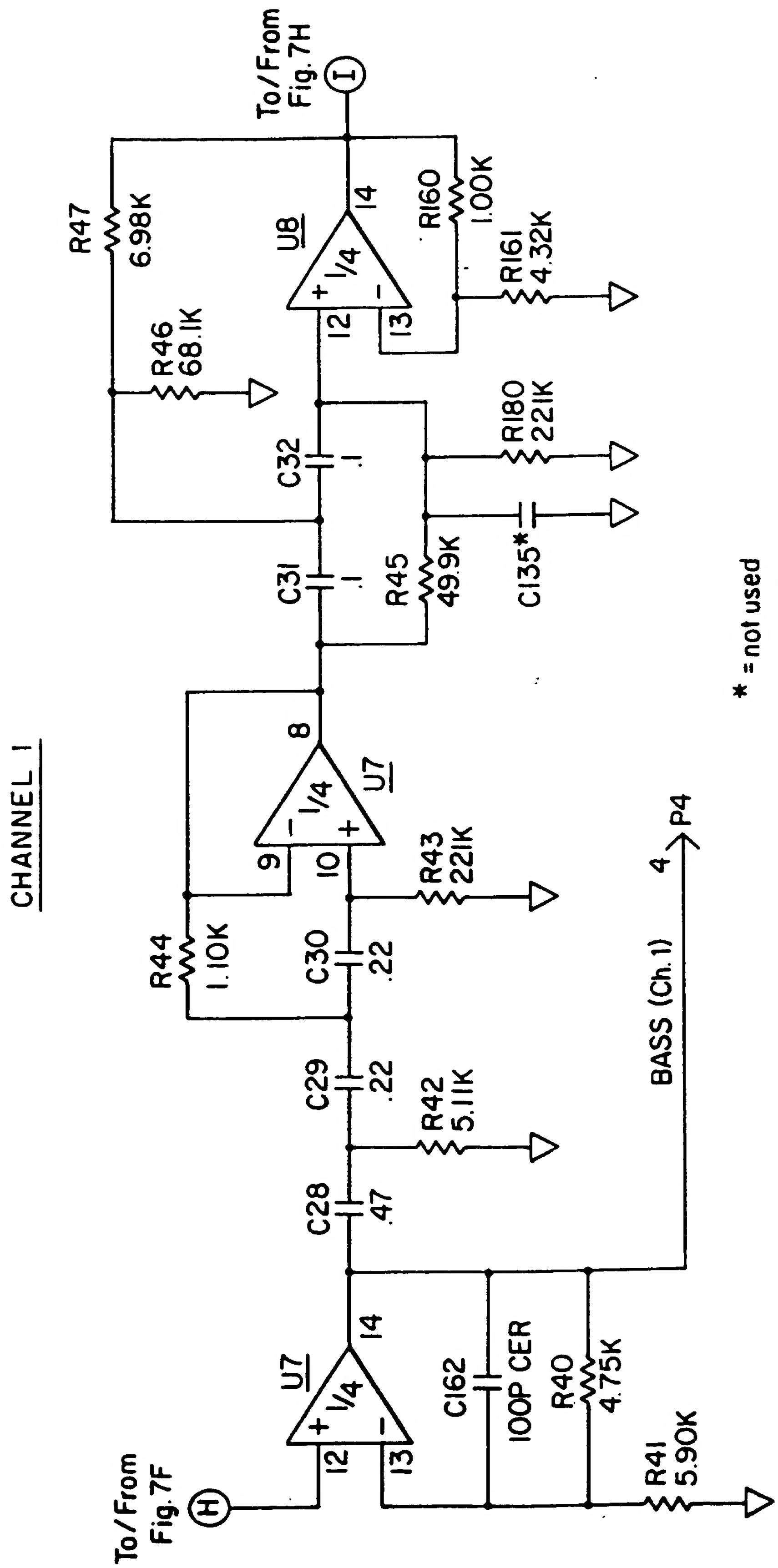

CHANNEL 1
To/From Fig. 7F
H
U7
1/4
12
13
14
C162
100P CER
R40
4.75K
R41
5.90K
C28
.47
R42
5.11K
C29
.22
R44
1.10K
C30
.22
R43
221K
9
10
8
U7
1/4
BASS (Ch. 1)
4
P4
C31
.1
R45
49.9K
C135*
C32
.1
R180
221K
R46
68.1K
R47
6.98K
U8
1/4
12
13
14
R160
1.00K
R161
4.32K
To/From Fig. 7H
I
* = not used

FIG. 7G

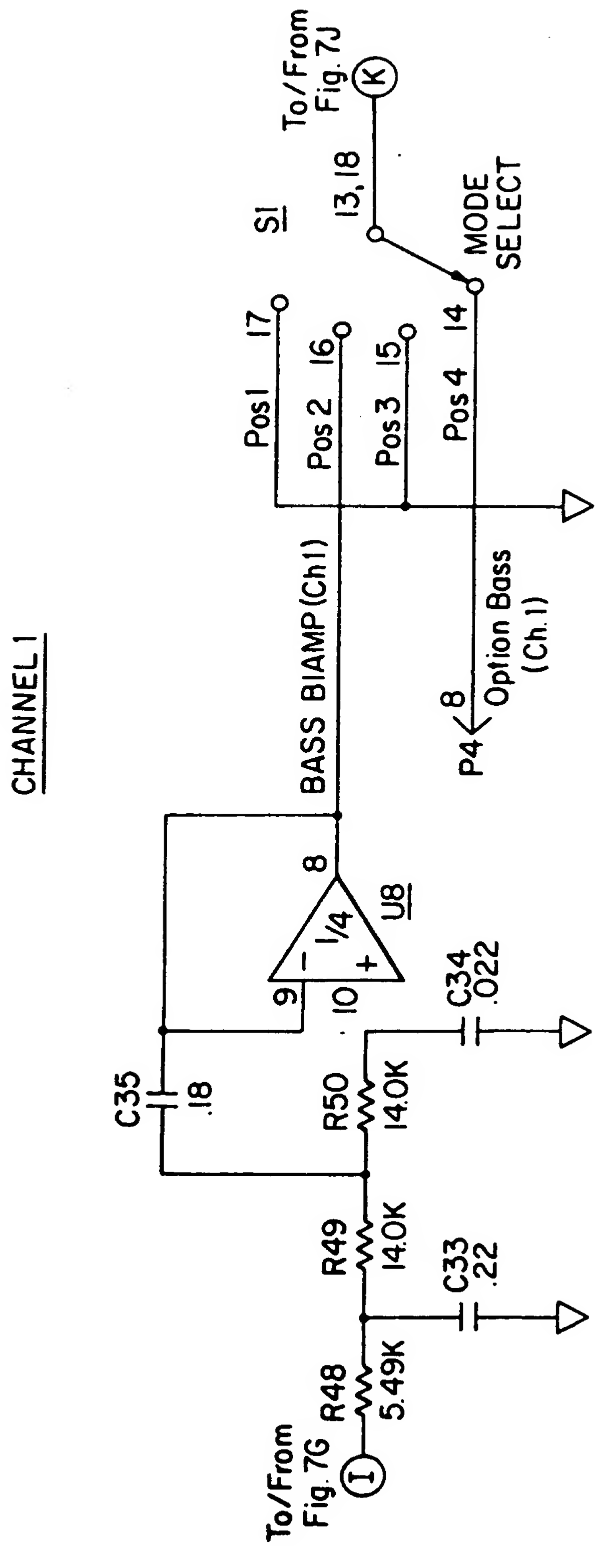

CHANNEL 1
To/From
Fig. 7G
I
R48
5.49K
C33
.22
R49
14.0K
C35
.18
R50
14.0K
C34
.022
9
10
1/4
U8
8
BASS BIAMP (Ch1)
Pos1
Pos 2
Pos 3
Pos 4
17
16
15
14
S1
13,18
MODE
SELECT
To/From
Fig. 7J
K
P4
8
Option Bass
(Ch.1)

FIG. 7H

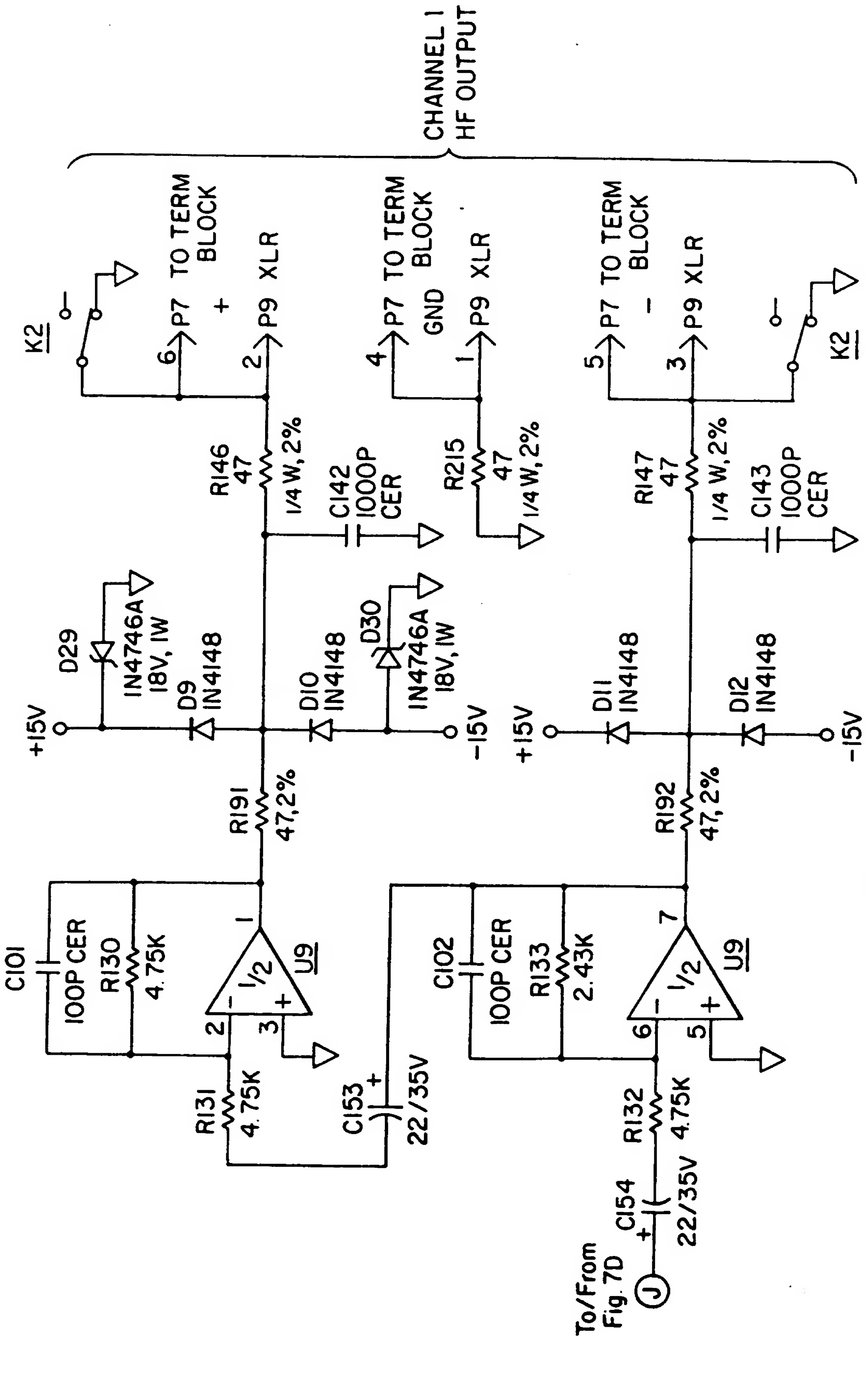

CHANNEL 1
HF OUTPUT
K2
P7 TO TERM BLOCK
P9 XLR
GND
R146 47 1/4 W, 2%
R215 47 1/4 W, 2%
R147 47 1/4 W, 2%
C142 1000P CER
C143 1000P CER
D29 1N4746A 18V, 1W
D30 1N4746A 18V, 1W
D9 1N4148
D10 1N4148
D11 1N4148
D12 1N4148
+15V
-15V
R191 47,2%
R192 47,2%
C101 100P CER
R130 4.75K
C102 100P CER
R133 2.43K
U9
1/2
R131 4.75K
C153 22/35V
R132 4.75K
C154 22/35V
To/From Fig. 7D
J

FIG. 7I

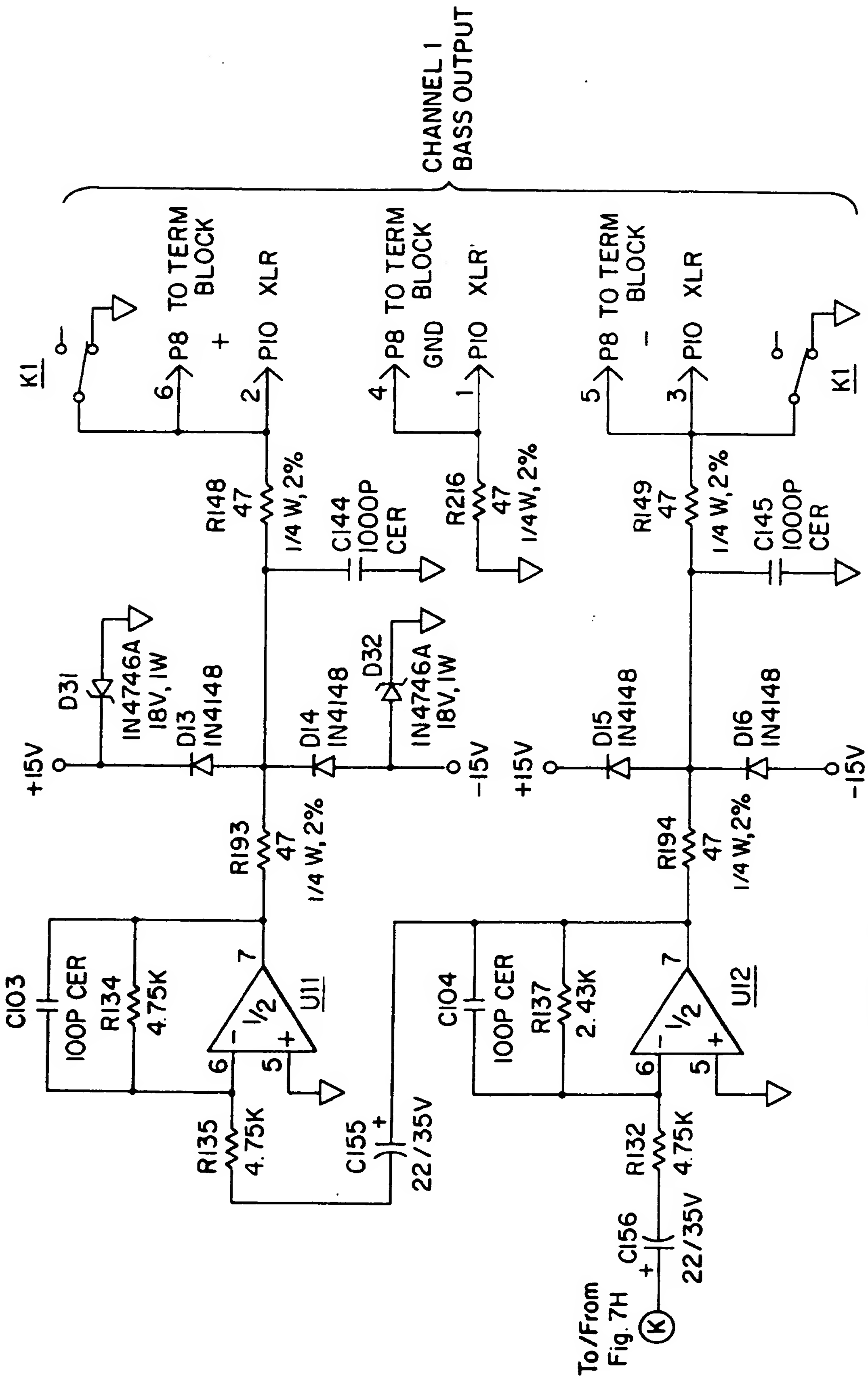

CHANNEL 1
BASS OUTPUT
K1
P8 TO TERM BLOCK
P10 XLR
GND
R148 47 1/4 W, 2%
R216 47 1/4W, 2%
R149 47 1/4 W, 2%
C144 1000P CER
C145 1000P CER
D31 1N4746A 18V, 1W
D32 1N4746A 18V, 1W
D13 1N4148
D14 1N4148
D15 1N4148
D16 1N4148
+15V
-15V
R193 47 1/4 W, 2%
R194 47 1/4 W, 2%
C103 100P CER
R134 4.75K
C104 100P CER
R137 2.43K
U11
U12
1/2
R135 4.75K
C155 22/35V
R132 4.75K
C156 22/35V
To/From Fig. 7H
K

FIG. 7J

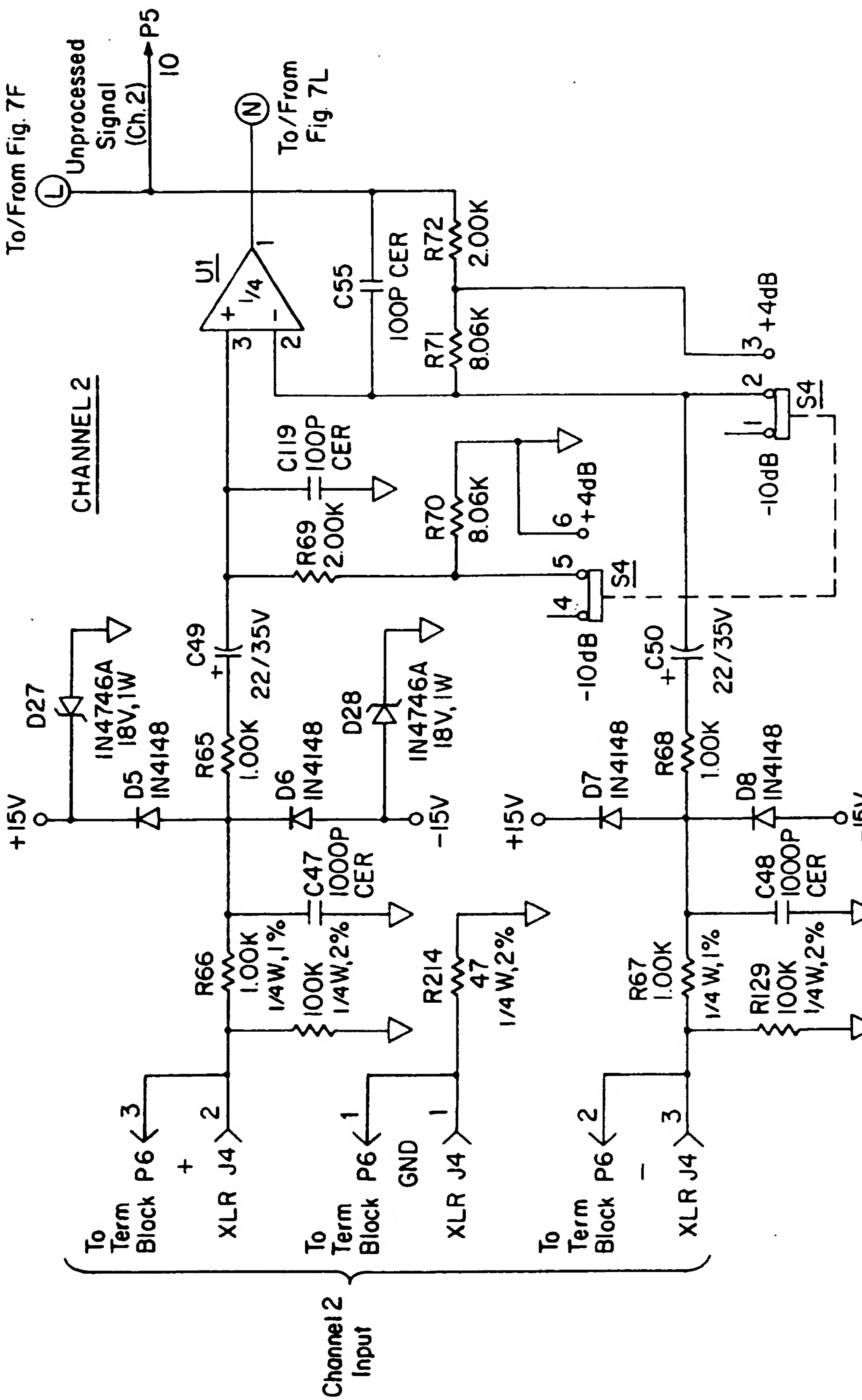

To/From Fig. 7F
L
Unprocessed Signal (Ch.2)
P5
10
N
To/From Fig. 7L
U1
1/4
C55
100P CER
R72
2.00K
R71
8.06K
+4dB
S4
-10dB
CHANNEL 2
C119
100P
CER
R69
2.00K
R70
8.06K
+4dB
S4
-10dB
D27
IN4746A
18V,1W
C49
22/35V
+15V
D5
IN4148
R65
1.00K
D6
IN4148
D28
IN4746A
18V,1W
-15V
+15V
D7
IN4148
R68
1.00K
C50
22/35V
D8
IN4148
-15V
C47
1000P
CER
R66
1.00K
1/4W,1%
100K
1/4W,2%
R214
47
1/4W,2%
C48
1000P
CER
R67
1.00K
1/4 W,1%
R129
100K
1/4W,2%
To Term Block P6
+
XLR J4
To Term Block P6
GND
XLR J4
To Term Block P6
-
XLR J4
Channel 2 Input

FIG. 7K

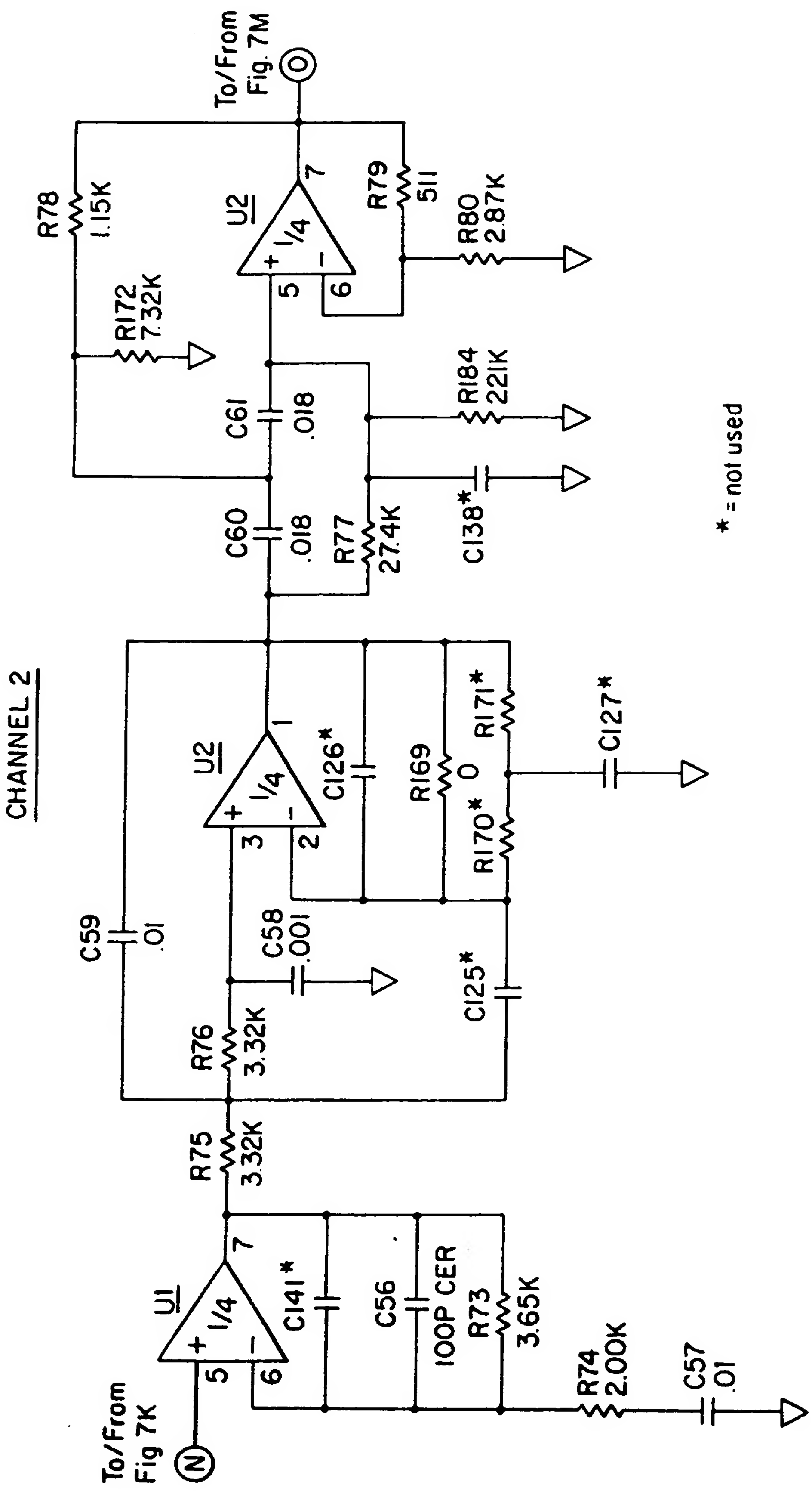

To/From
Fig. 7M
O
R78
1.15K
R172
7.32K
U2
1/4
5
6
7
R79
511
R80
2.87K
C61
.018
R184
221K
C60
.018
R77
27.4K
C138*
* = not used
CHANNEL 2
U2
1/4
3
2
1
C126*
R169
0
R171*
R170*
C127*
C59
.01
C58
.001
C125*
R76
3.32K
R75
3.32K
U1
1/4
5
6
7
C141*
C56
100P CER
R73
3.65K
R74
2.00K
C57
.01
To/From
Fig 7K
N

FIG. 7L

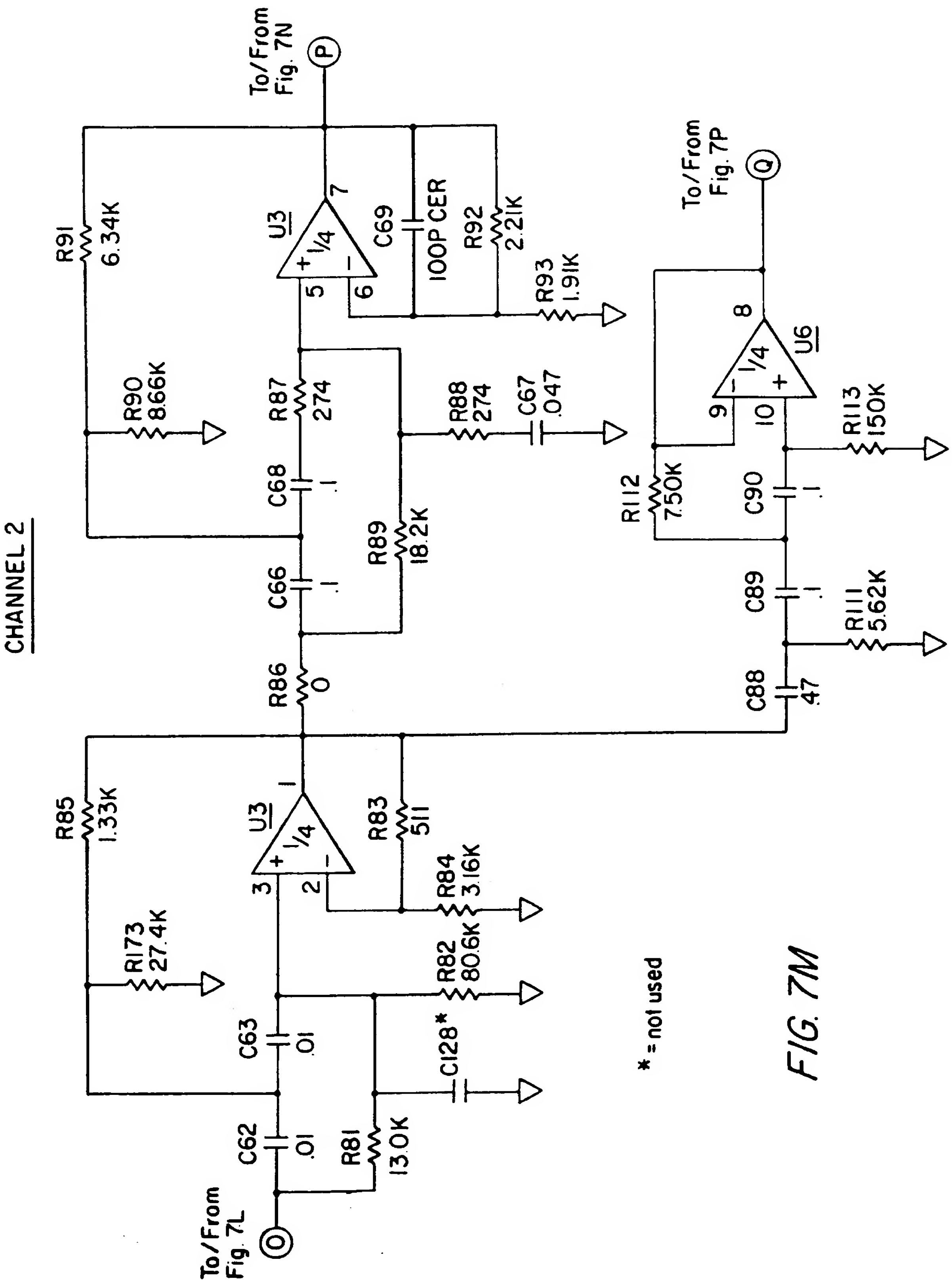

CHANNEL 2
To/From
Fig. 7N
P
To/From
Fig. 7P
Q
To/From
Fig. 7L
O
R91
6.34K
R90
8.66K
R85
1.33K
R173
27.4K
U3
1/4
U3
1/4
U6
1/4
C69
100P CER
R92
2.21K
R93
1.91K
R87
274
R88
274
C67
.047
C68
.1
C66
.1
R89
18.2K
R86
0
R83
511
R84
3.16K
R82
80.6K
C63
.01
C62
.01
R81
13.0K
C128*
R112
750K
C90
.1
C89
.1
C88
.47
R111
5.62K
R113
150K
* = not used

FIG. 7M

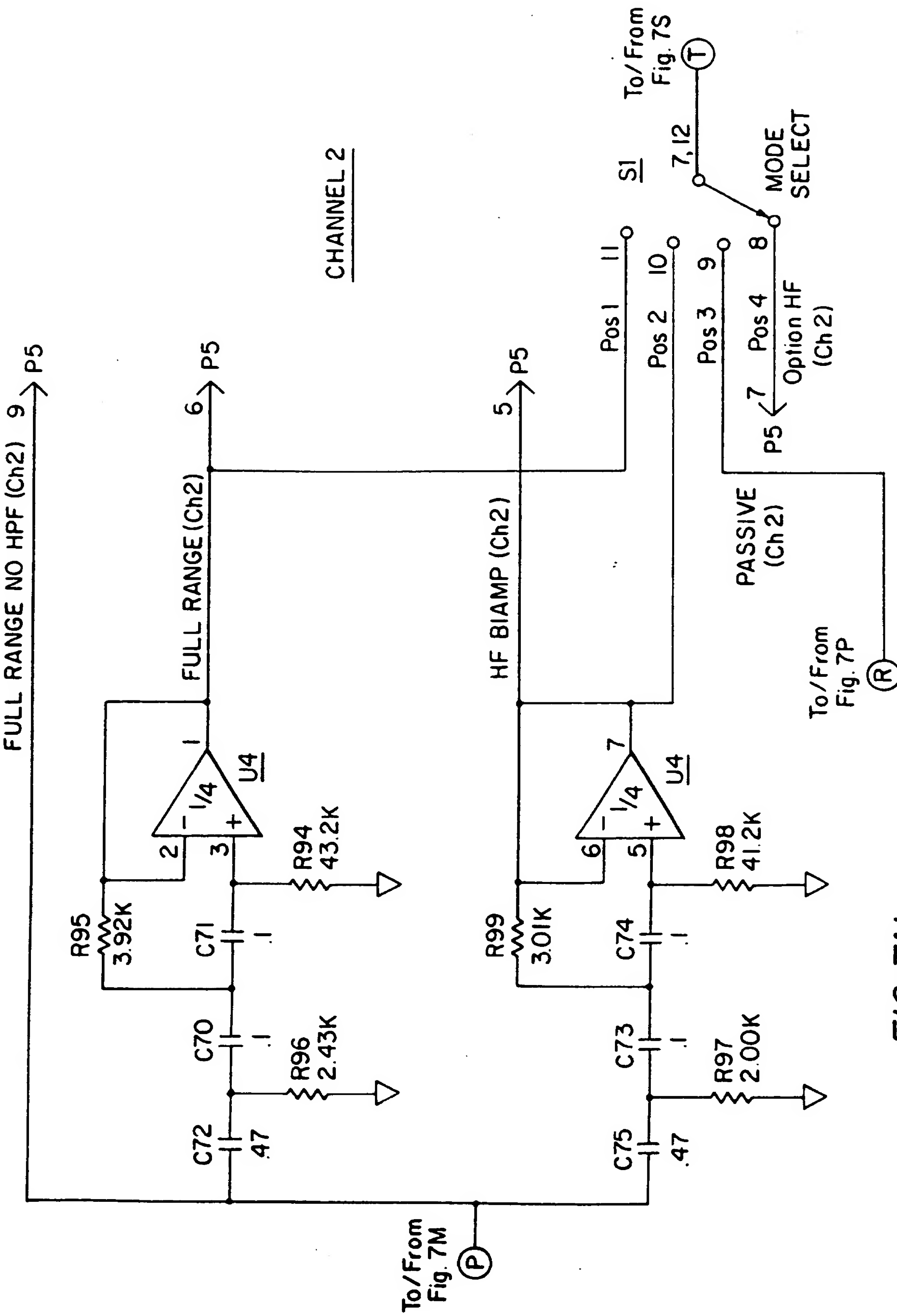

CHANNEL 2
FULL RANGE NO HPF (Ch2) 9 P5
FULL RANGE (Ch2) 6 P5
HF BIAMP (Ch2) 5 P5
Pos 1 11
Pos 2 10
Pos 3 9
Pos 4 8
Option HF (Ch 2)
P5 7
S1
7,12
MODE SELECT
To/From Fig. 7S
T
PASSIVE (Ch 2)
To/From Fig. 7P
R
To/From Fig. 7M
P
U4
1/4
R95 3.92K
R94 43.2K
R96 2.43K
C70 .1
C71 .1
C72 .47
R99 3.01K
R98 41.2K
R97 2.00K
C73 .1
C74 .1
C75 .47

FIG. 7N

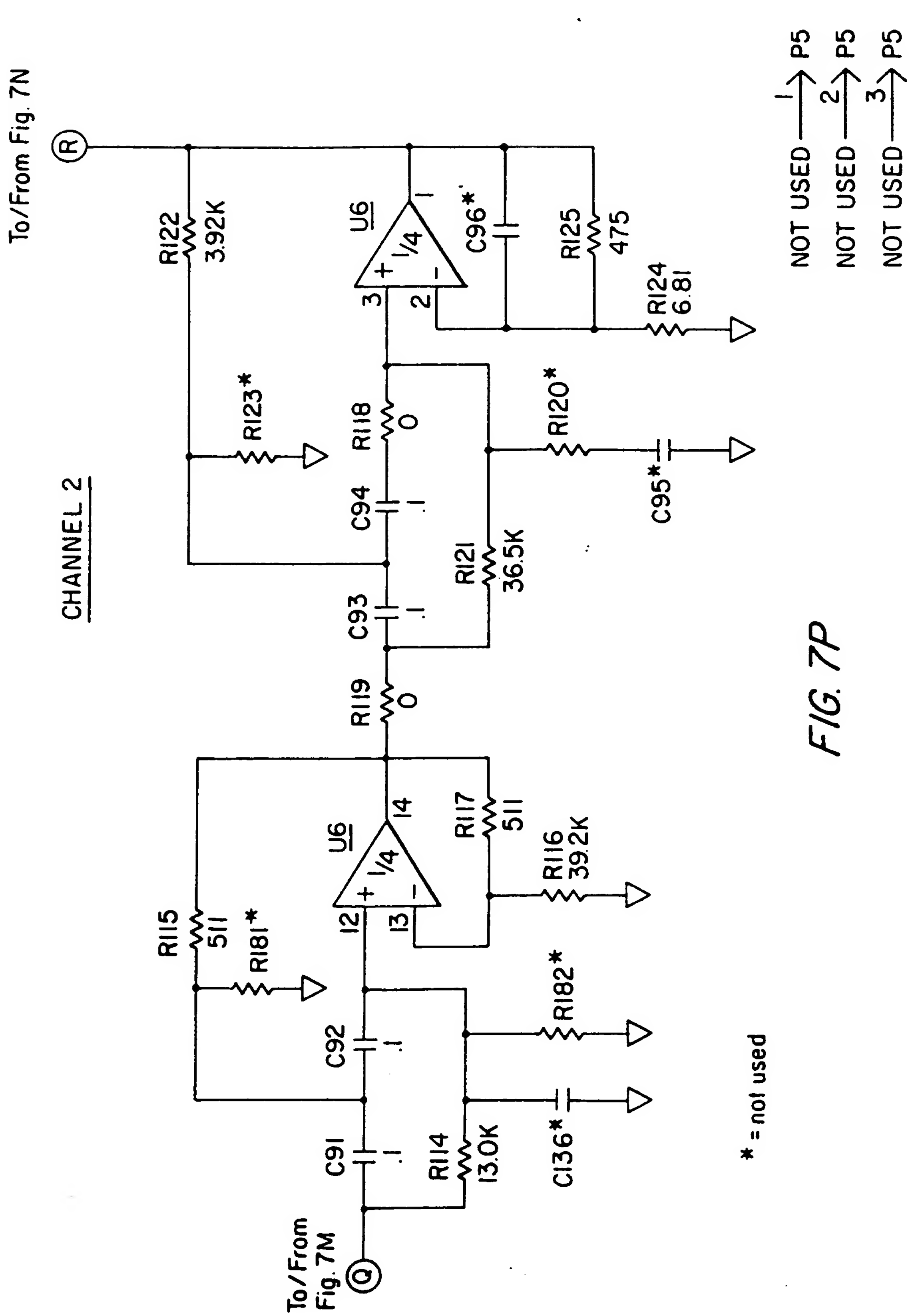

To/From Fig. 7N
R
CHANNEL 2
R122
3.92K
R123*
U6
1/4
+
-
3
2
1
C96*
R125
475
R124
6.81
R118
0
C94
.1
R120*
C95*
R121
36.5K
C93
.1
R119
0
U6
1/4
12
13
14
R117
511
R116
39.2K
R115
511
R181*
C92
.1
R182*
C91
.1
R114
13.0K
C136*
To/From
Fig. 7M
Q
NOT USED
1
P5
NOT USED
2
P5
NOT USED
3
P5
* = not used

FIG. 7P

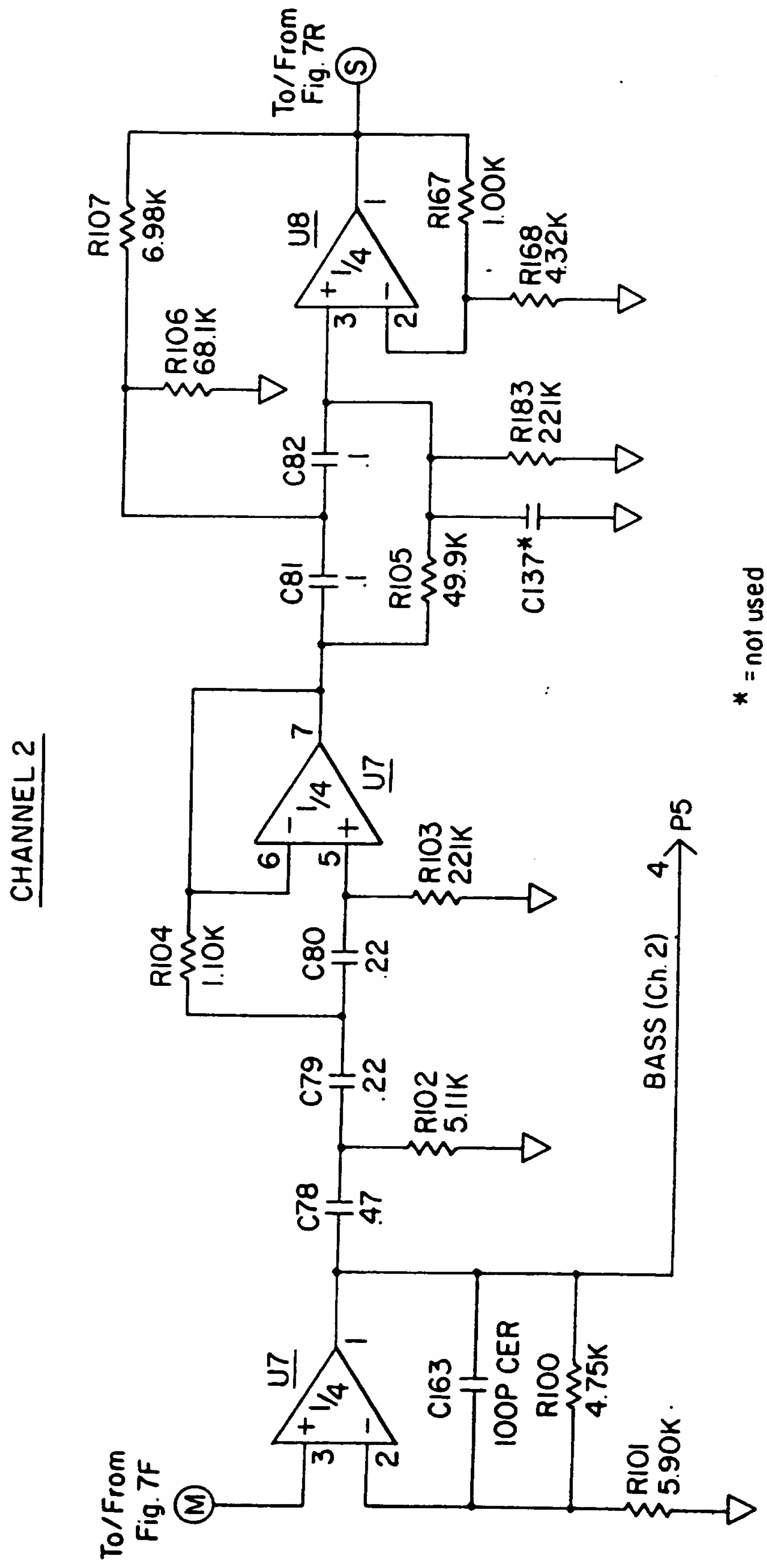

CHANNEL 2
To/From Fig. 7F
M
U7
1/4
3
2
1
C163
100P CER
R100
4.75K
R101
5.90K
C78
.47
R102
5.11K
C79
.22
R104
1.10K
C80
.22
R103
221K
U7
1/4
6
5
7
BASS (Ch. 2)
4
P5
C81
.1
R105
49.9K
C137*
C82
.1
R183
221K
R106
68.1K
R107
6.98K
U8
1/4
3
2
1
R167
1.00K
R168
4.32K
To/From Fig. 7R
S
* = not used

FIG. 7Q

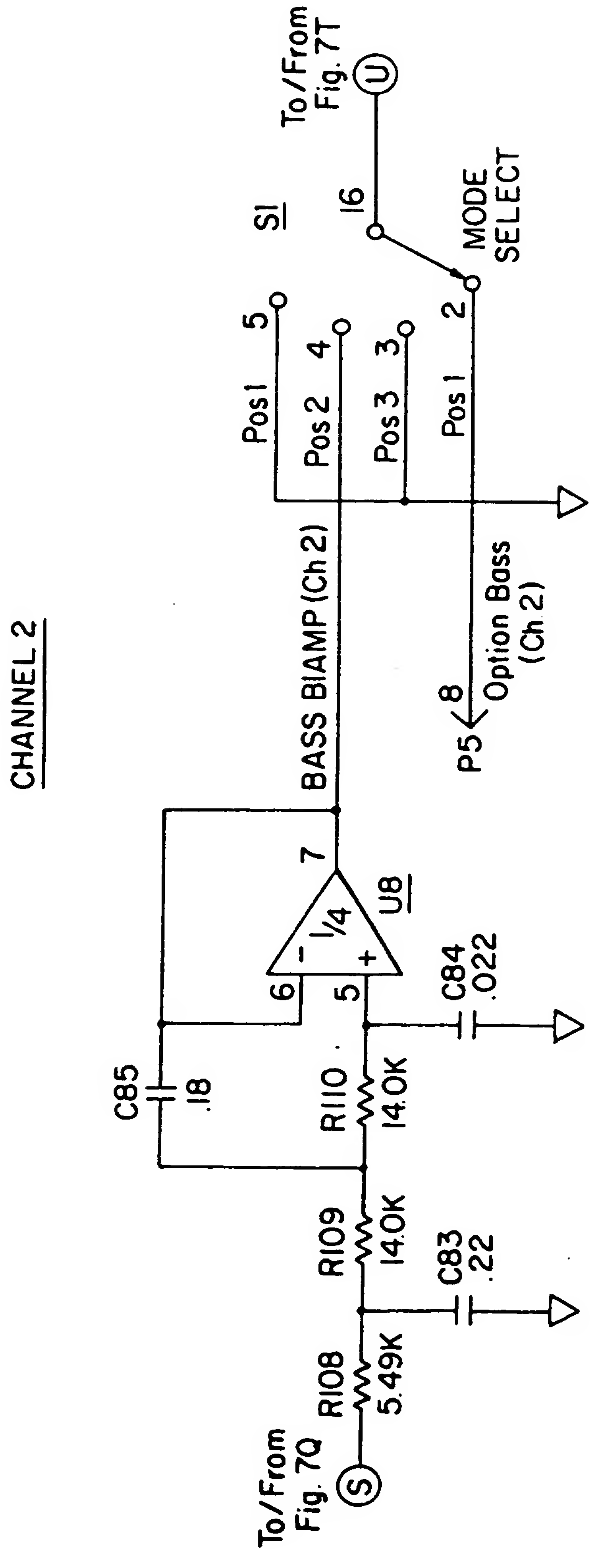

CHANNEL 2
To/From
Fig. 7Q
S
R108
5.49K
C83
.22
R109
14.0K
C85
.18
R110
14.0K
C84
.022
6
5
-
+
1/4
U8
7
BASS BIAMP (Ch 2)
P5
8
Option Bass
(Ch 2)
Pos 1
Pos 2
Pos 3
Pos 1
5
4
3
2
S1
16
MODE
SELECT
To/From
Fig. 7T
U

FIG. 7R

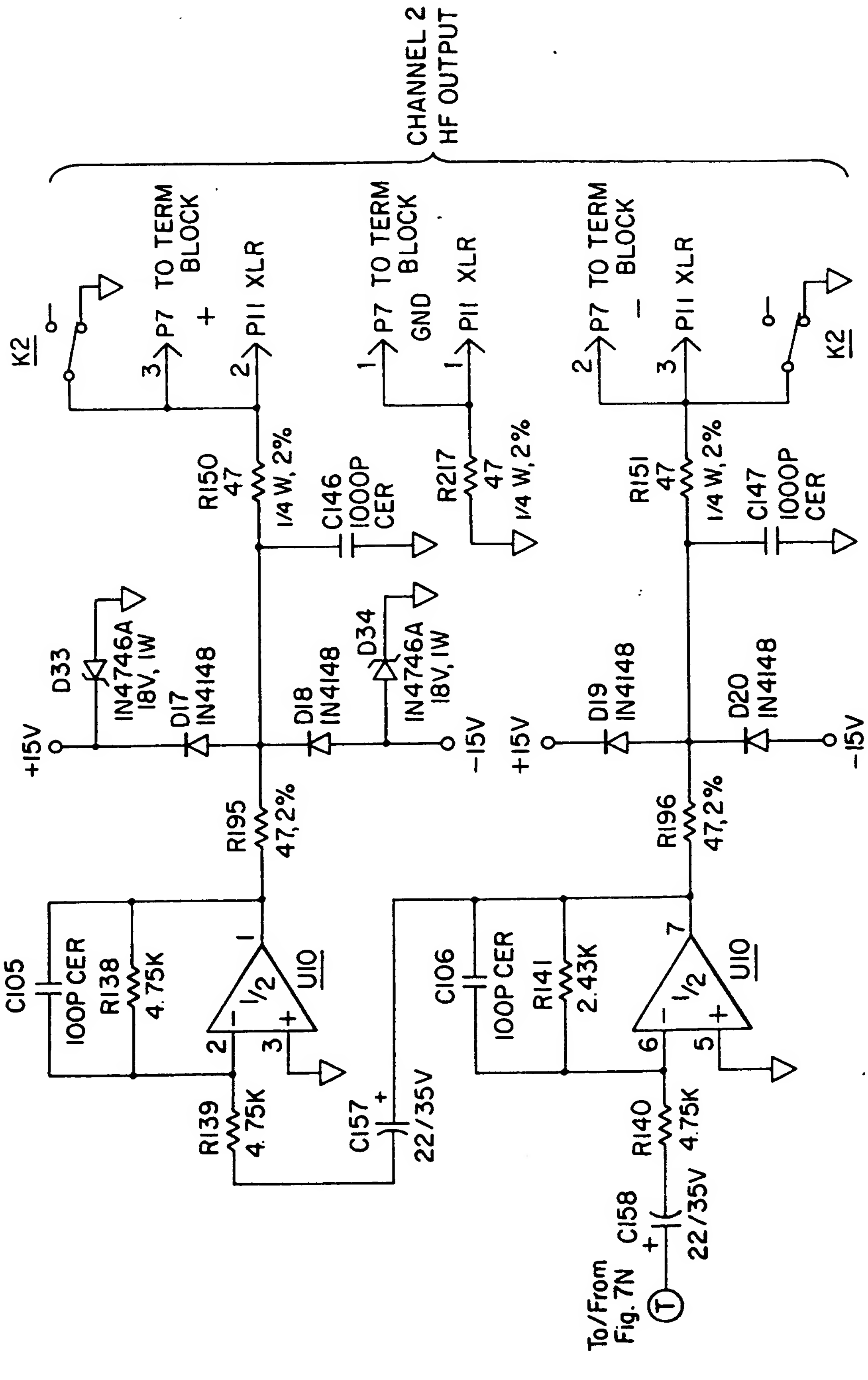

CHANNEL 2
HF OUTPUT
K2
P7 TO TERM BLOCK
+
P11 XLR
GND
−
R150
47
1/4 W, 2%
C146
1000P
CER
R217
47
1/4 W, 2%
R151
47
1/4 W, 2%
C147
1000P
CER
D33
1N4746A
18V, 1W
D17
1N4148
D18
1N4148
D34
1N4746A
18V, 1W
D19
1N4148
D20
1N4148
+15V
−15V
R195
47,2%
R196
47,2%
C105
100P CER
R138
4.75K
R139
4.75K
U10
1/2
C157
22/35V
C106
100P CER
R141
2.43K
R140
4.75K
C158
22/35V
To/From
Fig. 7N
T

FIG. 7S

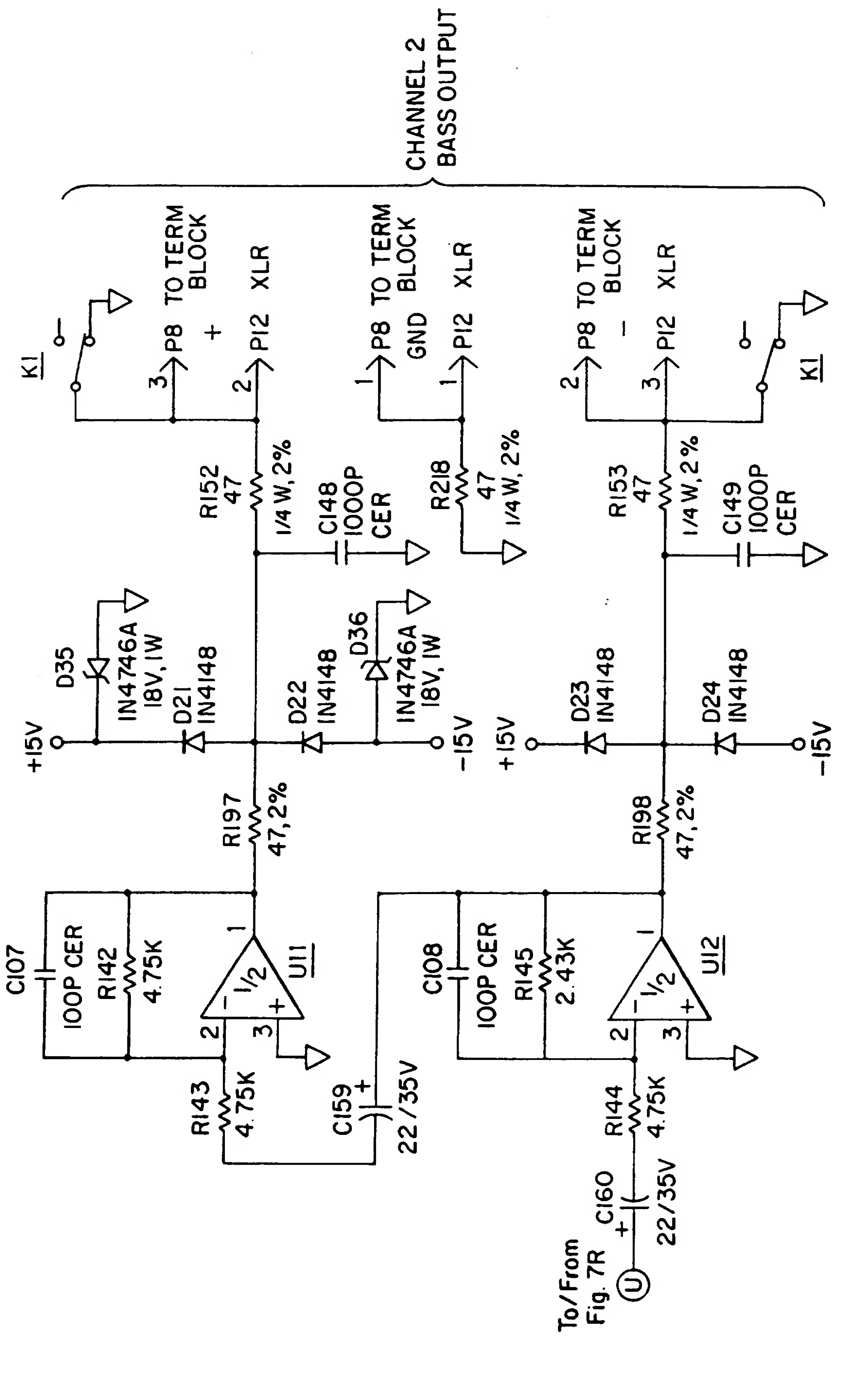

CHANNEL 2
BASS OUTPUT
K1
3
P8
TO TERM BLOCK
+
2
P12
XLR
1
P8
TO TERM BLOCK
GND
1
P12
XLR
2
P8
TO TERM BLOCK
-
3
P12
XLR
K1
R152
47
1/4 W, 2%
C148
1000P
CER
R218
47
1/4 W, 2%
R153
47
1/4 W, 2%
C149
1000P
CER
+15V
D35
IN4746A
18V, 1W
D21
IN4148
D22
IN4148
D36
IN4746A
18V, 1W
-15V
+15V
D23
IN4148
D24
IN4148
-15V
R197
47, 2%
R198
47, 2%
C107
100P CER
R142
4.75K
1/2
U11
C108
100P CER
R145
2.43K
1/2
U12
R143
4.75K
C159
22/35V
R144
4.75K
C160
22/35V
To/From
Fig. 7R
U

FIG. 7T

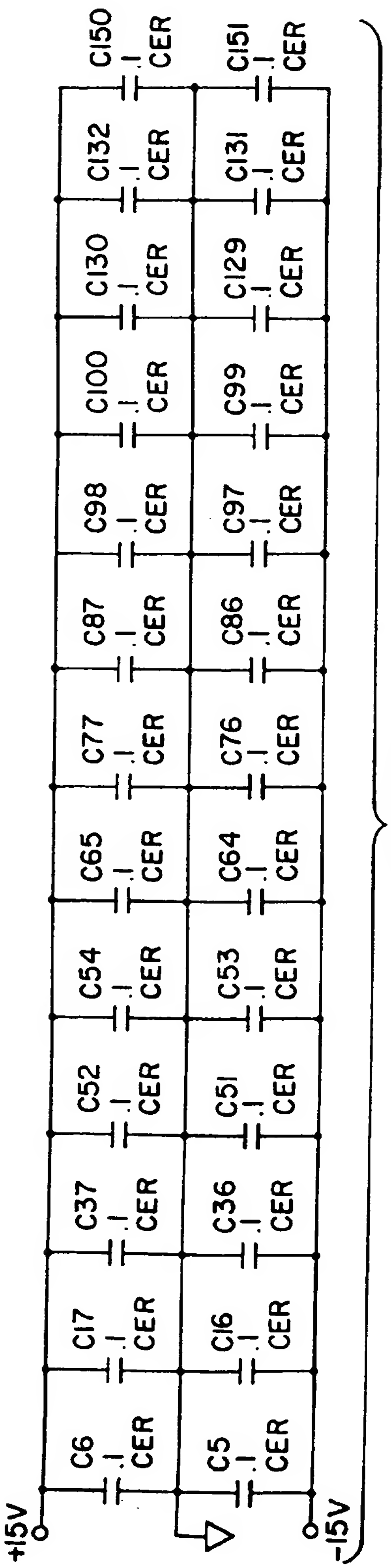

+15V
-15V
C6 .1 CER
C5 .1 CER
C17 .1 CER
C16 .1 CER
C37 .1 CER
C36 .1 CER
C52 .1 CER
C51 .1 CER
C54 .1 CER
C53 .1 CER
C65 .1 CER
C64 .1 CER
C77 .1 CER
C76 .1 CER
C87 .1 CER
C86 .1 CER
C98 .1 CER
C97 .1 CER
C100 .1 CER
C99 .1 CER
C130 .1 CER
C129 .1 CER
C132 .1 CER
C131 .1 CER
C150 .1 CER
C151 .1 CER

FIG. 7U

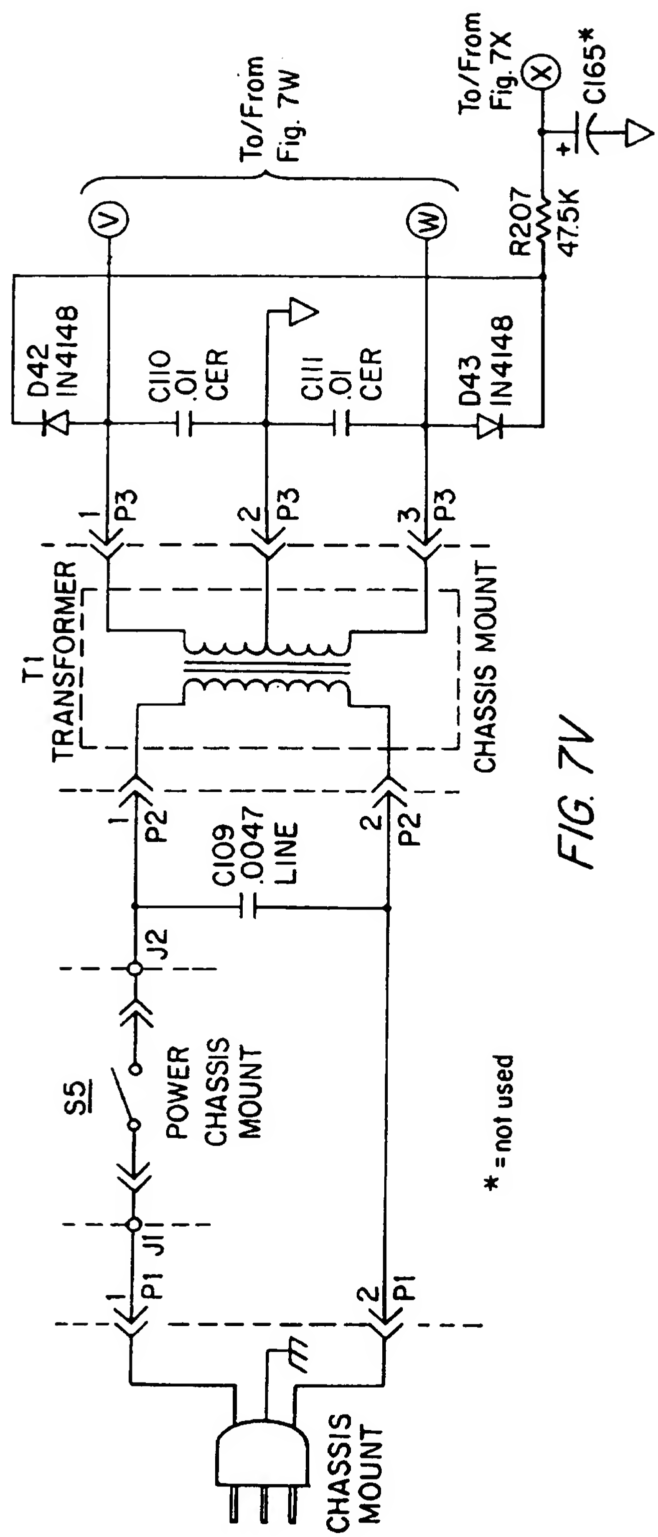

CHASSIS MOUNT
1 P1
2 P1
J1
S5
POWER CHASSIS MOUNT
J2
C109 .0047 LINE
1 P2
2 P2
T1 TRANSFORMER
CHASSIS MOUNT
1 P3
2 P3
3 P3
D42 IN4148
C110 .01 CER
C111 .01 CER
D43 IN4148
V
W
To/From Fig. 7W
R207 47.5K
+
C165*
X
To/From Fig. 7X
* =not used

FIG. 7V

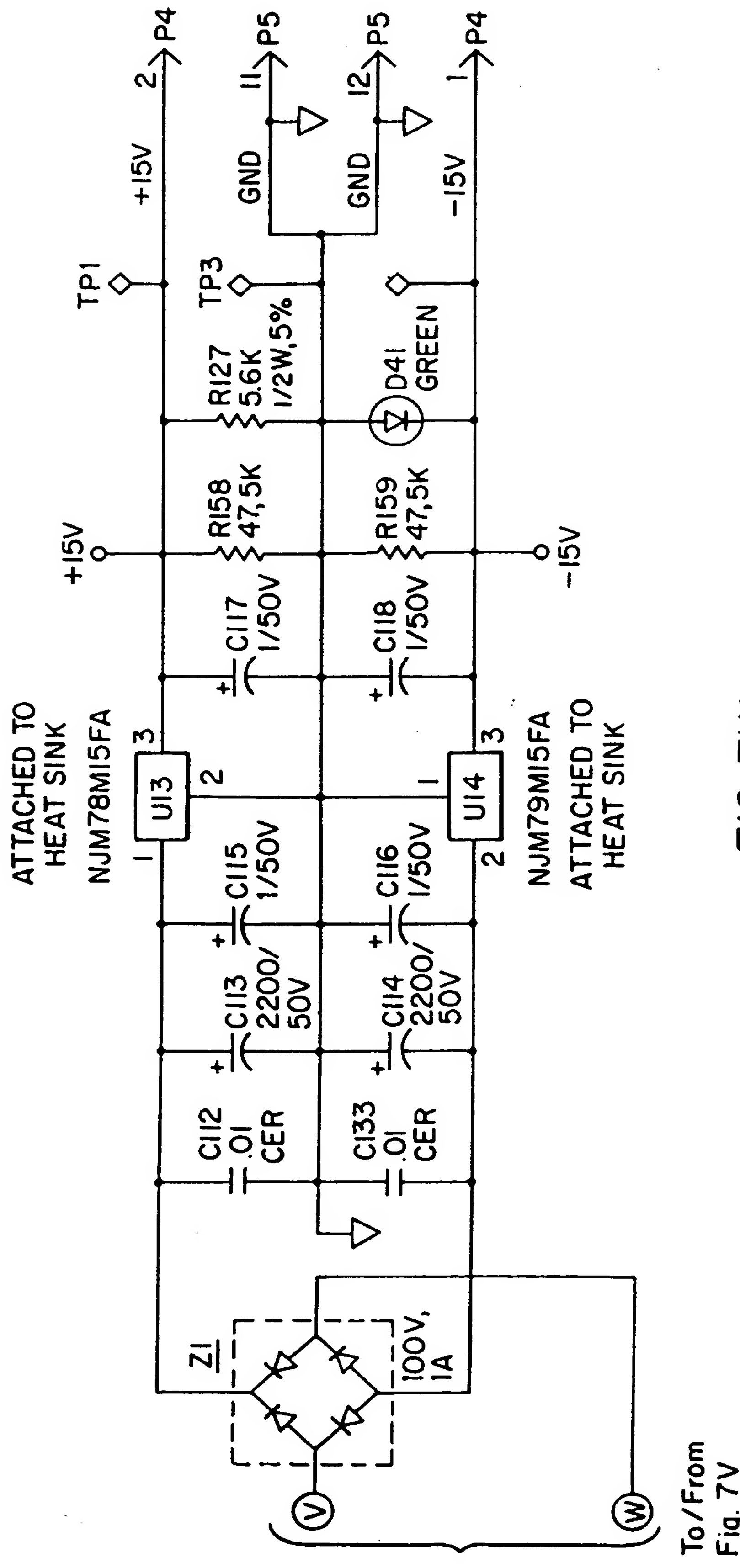

P4
P5
P5
P4
+15V
GND
GND
-15V
TP1
TP3
R127 5.6K 1/2W,5%
D41 GREEN
R158 47,5K
R159 47,5K
+15V
-15V
C117 1/50V
C118 1/50V
ATTACHED TO HEAT SINK
NJM78M15FA
U13
U14
NJM79M15FA
ATTACHED TO HEAT SINK
C115 1/50V
C116 1/50V
C113 2200/ 50V
C114 2200/ 50V
C112 .01 CER
C133 .01 CER
Z1
100V, 1A
V
W
To/From Fig. 7V

FIG. 7W

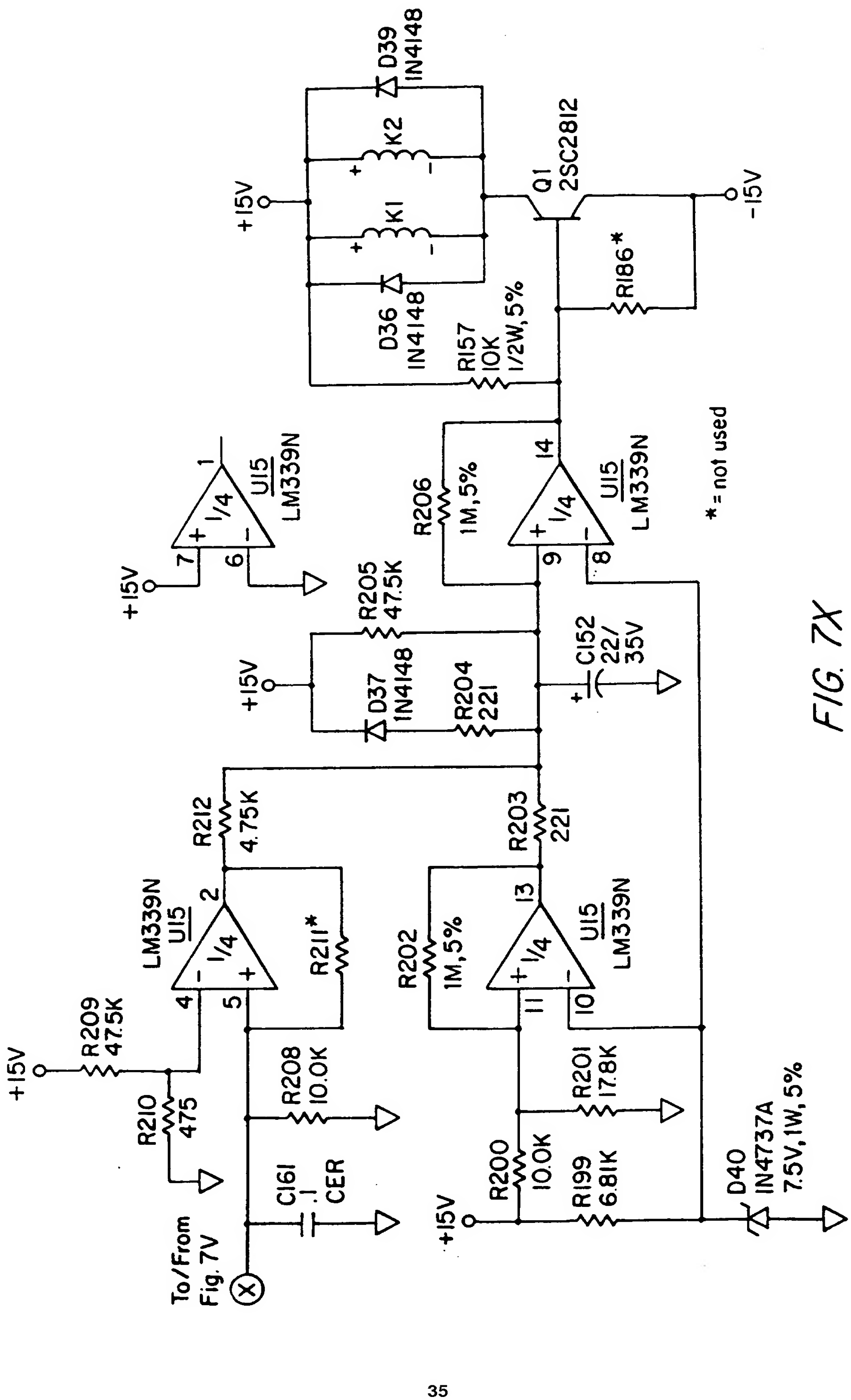

+15V
R209
47.5K
R210
475
To/From
Fig. 7V
C161
.1
CER
R208
10.0K
LM339N
U15
1/4
R211*
R212
4.75K
+15V
R200
10.0K
R199
6.81K
R201
17.8K
R202
1M,5%
U15
LM339N
R203
221
D40
1N4737A
7.5V,1W,5%
+15V
D37
1N4148
R204
221
R205
47.5K
C152
22/
35V
R206
1M,5%
U15
LM339N
*= not used
+15V
U15
LM339N
R157
10K
1/2W,5%
D36
1N4148
K1
K2
D39
1N4148
Q1
2SC2812
R186*
-15V

FIG. 7X